DOCUMENT RESUME

ED 055 786 24 SE 011 115

AUTHOR	Norris, Eleanor
TITLE	National Assessment of Educational Progress, Report 1--Science: National Results and Illustrations of Group Comparisons.
INSTITUTION	National Assessment of Educational Progress, Ann Arbor, Mich.
SPONS AGENCY	National Center for Educational Research and Development (DHEW/CE), Washington, D.C.
BUREAU NO	BR-8-0771
PUB DATE	Jul 70
NOTE	226p.
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (GPO 830-208, $1.75)
EDRS PRICE	MF-$0.65 HC-$9.87
DESCRIPTORS	*Evaluation; *National Competency Tests; National Surveys; *Natural Sciences; *Science Education; *Sciences; Science Tests; Scientific Attitudes; Scientific Concepts
IDENTIFIERS	National Assessment of Educational Progress

ABSTRACT

This publication, written for citizens and professional educators, releases about 40 percent of the data describing what groups of Americans know and can do in the area of science. Nine-year old elementary (28,000), thirteen-year old junior high (28,000), and senior high students were tested. In addition 10,000 adults, ages 26-35, were involved. Four major objectives assessed included: (1) Fundamental Facts and Principles of Science, (2) Abilities and Skills Needed to Engage in the Process of Science, (3) Understanding the Nature of Science, Attitudes and Appreciations of Scientists, Science, and (4) the Consequences of Science that Stem from Adequate Understandings. Data were analyzed to yield information regarding: (1) four geographic regions, (2) four sizes of communities, (3) four types of communities, (4) sex, and (5) levels of parents education. Appendices include the development of the National Assessment Exercises, Definition of Terms, Structure of Sampling and Weighting, and Data for Nine Selected Science Exercises. There is no attempt in this report to discuss whether these results show that the status of science education and knowledge in the United States is good or bad, or to make recommendations on the basis of these results. (BB)

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SCIENCE

NATIONAL RESULTS 1970

REPORT 1

NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS
A PROJECT OF THE EDUCATION COMMISSION OF THE STATES

NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

A Project of the Education Commission of the States

Tom McCall, Governor of Oregon, Chairman, Education Commission of the States
Wendell H. Pierce, Executive Director, Education Commission of the States
James A. Hazlett, Administrative Director, National Assessment

Assessment Reports

#1 Science: National Results — July, 1970

#2 Citizenship: National Results - - Partial — July, 1970

In addition to the detailed reports of National Assessment, brief summaries of the results and commentaries by a panel of reviewers are available.

-0-

The project reported herein was performed pursuant to a grant from the National Center for Educational Research and Development, U. S. Office of Education, Department of Health, Education, and Welfare. However, the opinions expressed herein do not necessarily reflect the position or policy of the U. S. Office of Education, and no official endorsement by the U. S. Office of Education should be inferred.

This report was made possible in part by funds granted by Carnegie Corporation of New York. The statements made and views expressed are solely the responsibility of National Assessment of Educational Progress, a project of the Education Commission of the States.

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NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

A Project of the Education Commission of the States

REPORT 1

1969-1970 SCIENCE: NATIONAL RESULTS AND ILLUSTRATIONS OF GROUP COMPARISONS

July, 1970

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402
Price $1.75

National Assessment Report 1:

Science National Results

Additional reports giving more detailed analyses of data will be published in coming months.

The texts of these exercises have been released. The texts are only part of how the exercises were given. Reuse of the texts alone cannot be expected to produce results that can be compared with those given here.

Although this report is the product of the efforts and creativity of many people, the following individuals contributed most directly to its preparation.

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ACKNOWLEDGEMENTS

The number of persons who have made substantial contributions to this report, from the beginning of National Assessment in 1964 to this initial reporting in 1970, would comprise almost a book in itself. Active guidance of the project during its formative stages was with Ralph Tyler and the Exploratory Committee on Assessing the Progress of Education. The details of the plan itself were developed by the Technical Advisory Committee (now called the Analysis Advisory Committee, ANAC) and staff directors Stephen Withey and Jack Merwin. As the operational phase began, the Exploratory Committee, expanded in membership, became the Committee on Assessing the Progress of Education, chaired by George Brain. A year ago National Assessment became a project of the Education Commission of the States, with active direction from a Policy Committee chaired by James Hazlett.

Original preparation of objectives and exercises in the Science area was by the Educational Testing Service. Review of these materials was made by dozens of consultants, both subject matter specialists and lay persons, under the general monitoring role of the National Assessment staff. Administration of exercises was handled by the Research Triangle Institute (RTI) and the Measurement Research Center (MRC). Scoring and processing were handled by MRC. Analysis of results was handled by MRC, by Perry Gluckman (consultant) and by NAEP staff members Irvin Lehmann, Dale Foreman, David Bayless, Jim Robinson, and Virginia Goslin. ANAC initiated most analyses and reviewed all of them. Preparation of this report was done by Eleanor Norris, with the help of John Milholland, John Bowes, Lisa MacDonald, Alice Levin, Sue Smith, and Stephen Fick. Other members of NAEP staff reviewed the manuscript.

Special acknowledgement goes to the late Herbert Conrad, USOE Project Director for National Assessment, whose counsel and advice were available for the entire project after the operational phase began.

No words can sufficiently pay tribute to the dedicated efforts of staff, RTI, MRC, and consultants who accepted the impossible task of both analyzing these data and preparing reports from the time data collection was completed in February of 1970 and the time that this report was published in July of 1970. Only those who have been involved in similar crash programs will fully appreciate the hundreds of evenings and weekends of effort that were necessary to meet the goal of July reporting. Without a group of people truly dedicated to National Assessment and to the goal of helping to move American education forward, it would not have been accomplished.

Frank B. Womer
Staff Director

FOREWORD

The Education Commission of the States assumed full responsibility for managing the National Assessment program on July 1, 1969, because of its interest in accountability and after it had been requested by educational organizations who felt that the Commission was broadly based and appropriately responsible to the public. The Education Commission of the States through its Steering Committee is kept informed of National Assessment by means of an 11-member Policy Committee and a 28-member Advisory Committee. The Commission is ultimately responsible not only for continuing management but for possible changes in emphasis and direction.

Readers of the first two National Assessment reports on Science and Citizenship results should approach the reports and data discussed therein with a number of cautions. It is important that they do so because, even after five years, the purposes, design and potential usefulness of National Assessment have not been fully or widely understood or exhaustively explored.

Among the cautions are the following:

1. The two reports issued on July 8, 1970, are partial reports of the first year of data gathering. They are partial in that

   a. they cover only two of the 10 subject areas in the overall design, namely Science and Citizenship,

   b. they provide only national results in these two subject areas,

   c. the Citizenship results cover only three of the nine categories to be reported.

Subsequent reports will (1) report results in Writing, the third subject area already assessed; (2) provide analysis of data in all three subject areas by region, color, sex, community and family characteristics; and (3) complete the Citizenship results. To analyze the data collected from approximately 100,000 respondents and to present the results in interesting, reliable, and meaningful ways takes time.

The National Assessment Policy Committee agreed, however, that it was desirable to issue a partial report to the public as soon as possible. The first two reports, although partial, are final in terms of the information they present. They furthermore render the important service of making clear and concrete the purposes and scope of National Assessment.

2. A second caution is that the reporting of the results for the first time in any subject area will not provide a measure of the progress of learning of the populations assessed. The first reporting in a given subject provides "bench-mark data" against which the results of later assessments in that subject can be compared. One of the most important aspects of Assessment is the possibility of making comparisons over time of progress or lack of progress in a given subject area. To realize this objective of observing change over time in all 10 subject areas, will take more than a decade. However, since Reading, Science, and Mathematics will be assessed every three years (the other seven subjects--Art, Music, Writing, Social Studies, Citizenship, Career and Occupational Development, and Literature--are to be assessed every six years) there can be useful comparisons in Science after three years, and similarly, more frequent comparisons in Reading and Mathematics. Realizing this important goal means a continuous operation, continuous funding and - - patience. As National Assessment continues through the years with adequate funds, it will make an important contribution as an "educational indicator" in our national life.

3. It should be emphasized that National Assessment is designed to provide national and regional pictures of educational attainment. National Assessment will not report about individual states or parts thereof. (National Assessment was almost aborted in the developmental stages because of fears that it might "intrude" itself into the evaluation of state and local school systems.)

4. National Assessment is a new venture in educational evaluation. Its purpose in providing descriptive census-like information is relatively simple. In scope and methodology, however, it is innovative and complex in many ways. It is the first assessment of educational achievement on a national scale. It relies on a large sampling base determined

by complicated sampling procedures. It has developed its own questions (exercises) employing some new approaches. It has formulated learning objectives in behavioral terms through the involvement of many people with different backgrounds and has publicized these objectives. It has developed exercises designed for public understanding covering greater ranges of difficulty than those found in standardized tests--exercises that measure the stated objectives in behavioral terms. It reports results, not in terms of scores, standards or norms, but by publishing actual items and showing percentage choices for alternative answers. It intends to use traditional statistical analyses and is amenable to the employment of new analytical techniques.

Because National Assessment is a new venture in educational measurement, the designers, the working staff, the Policy Committee and the sponsors wish to emphasize that:

> National Assessment is, even as it is about to enter a second year of data-gathering (in Reading and Literature), an evolving mechanism, studying itself and receptive to suggestions for improvement.
>
> National Assessment results are released by the Education Commission of the States without drawing conclusions about their implications for educational policy. National Assessment supplies information, not "answers." The seeking of "answers" is recognized as desirable and it is the hope of National Assessment that it can provide "facts" that will assist others in part through the formulation and conduct of research projects to find "answers."

National Assessment is a large and complex program. To meet the central goals, it must continue to develop further both methods of measurement and methods of analysis and presentation. To find the "facts" is the challenge.

National Assessment is a program of educational product measurement consistent with the current desire to determine the yield of the educational dollar. It is hoped that it may encourage other more refined and localized approaches to determining accountability.

James A. Hazlett
Administrative Director for National Assessment
and Chairman of the Policy Committee

Wendell H. Pierce
Executive Director
Education Commission of the States

1.

NATIONAL ASSESSMENT OF SCIENCE[1]

In 1964, the Exploratory Committee on Assessing the Progress of Education (ECAPE) was established to determine the feasibility of conducting a study which would assess the educational attainments of Americans and, if this proved possible, to develop the plan and the instruments for its conduct. As a consequence of their efforts, the National Assessment of Educational Progress came into being. Its name stresses several important points: it is national in scope, and its focus is the assessment of the level of educational attainment--assessment not only at one point in time, but at various times so that it will be possible to determine whether progress in knowledge, skills, understandings, and attitudes is occurring.

The plan which ECAPE developed included 10 subject areas: Reading, Writing, and Mathematics, representing the traditional 3 Rs; Social Studies, Citizenship, Science, Art, Music, Literature, and Vocational Education. Vocational Education has now evolved into a broader area which is called Career and Occupational Development.

Each of these subject areas will be assessed periodically so that change over time can be observed. Science, Reading, and Mathematics are to be assessed every three years, while the other subject areas will be on a six-year cycle.

[1] For more detailed information on National Assessment, see Womer, Frank B. What is National Assessment? Ann Arbor, Michigan: National Assessment of Educational Progress, 1970;

Merwin, Jack D. and Womer, Frank B. Evaluation in assessing the progress of education to provide bases of public understanding and public policy. In NSSE Yearbook. Educational Evaluation: New Roles, New Means. Chicago, Illinois: University of Chicago Press, 1969.

Four age levels were selected: 9-year-olds, most of whom have completed their early primary education; 13-year-olds, most of whom have completed intermediate education; 17-year-olds, most of whom are approaching the end of high school; and young adults between 26 and 35, nearly all of whom have completed their formal education. In the 17-year-old group, it was planned to measure those still in school and those no longer in school (drop-outs, plus youngsters who had completed high school earlier than usual).

The plan calls for exercises judged appropriate by scholars, by school people, and by thoughtful citizens, and which were valid from a technical point of view. Exercises were worded to simplify them as much as possible so that they would present no irrelevant difficulties of statement or presentation. Generating reasonably satisfactory exercises took considerable time. (Appendix A provides a more detailed discussion of exercise development procedures. The four Science objectives are listed on page A-2.)

Gathering the Data

By 1969 the plan and the materials for carrying it out were sufficiently advanced that data could be gathered in three areas--Citizenship, Science, and Writing. A statistically designed sample at each of the four age levels was asked to respond to National Assessment materials. Data were collected from approximately 28,000 people in each of the three younger age groups, and from about 10,000 Adults, a total of almost 100,000 individuals.

The Science, Writing, and Citizenship exercises administered in the first year were divided into 14 "packages" for age 17, 13 for age 13, 10 for age 9, and 10 for Adults (a package is a booklet of exercises). When each of the respondents at the three younger ages had completed his package, there were approximately 2,000 responses to each package and thus to each exercise. The number of responses allows moderately precise statements about the knowledge of all people at an age level and less precise statements about the knowledge of people in such groups as those defined by geographical region,

sex, and so forth. The number of young adults taking any given package ranged from about 650 to 900. These smaller numbers usually led to less precise statements about Adults.

More than 2,500 schools throughout the country cooperated in National Assessment, allowing project staff to administer exercises to the student sample. Young adults and out-of-school 17-year-olds were assessed in their homes.

Field operations began in March, 1969, with the 17-year-old in-school assessment. During the summer, Adults and out-of-school 17-year-olds were assessed. Finally, the 13-and 9-year-olds were assessed in the fall and winter of 1969-70.

A number of unique procedures were used in the administration. A trained field staff conducted the administration in and out of school. During in-school administrations, instructions and exercises were read aloud by a tape-recorded voice as a group of students followed along in their booklets. This increased the uniformity of administration throughout the country, and also assisted youngsters with reading problems to understand what was being asked of them.

Other exercises were administered individually by trained interviewers who read each exercise aloud, and then recorded the response. A few exercises required use of scientific apparatus as a basis for answering questions.

Reporting Results

The first year of the data-gathering operations ended in February, 1970. The first results for Science appear in this volume; the first partial results for Citizenship are in a separate publication. Additional reports on Citizenship and Writing will appear in coming months; these will be followed by more detailed reports on all three areas.

National Assessment was designed to describe what groups of Americans have learned. In distinct contrast to tests which give each student a score, and compare him with a norm or examine school averages, National Assessment describes cross-sectional samples of people--how many of them know this, or how many can do that?

Table 1-1 shows the national results for one exercise.

Table 1-1

(● indicates correct answer)

In terms of the theory of natural selection, what is the explanation of why giraffes have come to have such long necks?

Age 13	*Age 17*		
8%	*12%*	*O*	*Stretching to get food in high trees has made their necks longer.*
2	*1*	*O*	*There is something inside of giraffes which keeps making longer necks.*
11	*6*	*O*	*Giraffe food contained vitamins which caused the vertebrae to lengthen.*
28	*13*	*O*	*Giraffe necks have gotten longer and longer as time has gone on, but nobody has any idea why this is.*
38	*58*	●	*Giraffes born with the longest necks have been able to stay alive when food was scarce and have passed this trait on to their offspring.*
12	*10*	*O*	*I don't know.*
0	*0*		*No Response*
99%	*100%*		

Notice that 20% more 17-year-olds than 13-year-olds gave the correct answer; more than a fourth of the 13s answered that nobody knows why giraffes' necks have gotten longer, while only 13% of the 17s chose this answer.

Reports of this character are released here for some 40% of the exercises used during the first Science assessment. Sixty percent of the exercises were held back, and can be used when Science is again assessed without fear that some schools might have "taught to" those specific exercises. This will allow a direct and fair comparison to give evidence of educational progress.

The form of National Assessment results is unfamiliar. There are no scores for individuals. There is no summary figure which describes how well any one objective or subobjective is being achieved. There are no norms against which to compare the percentages of success on individual exercises. This is to be expected, since National Assessment was not designed to provide any of these.

What National Assessment does provide is the first description on a nation-wide basis of various educational attainments of groups of Americans. How many young Americans, for example, have acquired specified abilities and skills needed to engage in the scientific process? How do 13-year-olds compare in each of these with 17-year-olds? With young adults?

National Assessment reports show what information people have, and also what misinformation people have. For a multiple-choice exercise, for example, this report gives the percentages marking each wrong choice. Knowledge as to what people mistakenly think is correct can also be useful in educational planning.

Plan for This Report

This report centers on national results, that is, on the percentages of people throughout the country at each age responding successfully and unsuccessfully to each of the released exercises.

An effort was made to write exercises usable at more than one age level, so that comparisons could be made from age to age. (Table 1-1 has already illustrated this.) Such comparisons appear in the next chapter.

National Assessment will in later months provide results for a variety of population groups. Detailed descriptions of four regions, four sizes of community, four types of community, and four levels of parents' education appear in Appendix B. Sex and color (Black and non-Black) will also serve as bases for analysis. Selected group comparisons are made on 10 Science exercises to illustrate the kinds of analyses which will be forthcoming for all exercises.

A word about sampling. The respondents were selected according to a nation-wide probability sampling plan intended to combine relatively high accuracy with relatively low cost. Certain groups (such as out-of-school 17s) would have been too expensive to sample as heavily as their share of the population would warrant; the respondents in such groups thus had to be more heavily weighted to yield results appropriate for the whole age level. All the percentages[2] in this report are based on appropriately weighted figures and thus refer to the populations tapped by the samples.

Selection for release. Figues 1-1 to 1-4 show the percentage responding correctly for all Science exercises, released and unreleased. Exercises are reasonably well spread from very easy to very hard, althought it may be seen that few difficult exercises were prepared for ages 9 and 13.

Exercises released should be representative of all the exercises given, matching both overall percentages of success and differences among groups. Figures 1-1 to 1-4 show how well the released exercises are matched in overall success to those held for reuse. (If an exercise used at more than one age was released at one age, it was automatically released at all ages.) Matching for group differences is about as satisfactory, as well be seen in the next reports.

[2] Throughout this report, percentages are rounded to the nearest whole percent, and percentages of less than one-half of one percent are reported as 0. Totals may add up to slightly less or slightly more than 100% because of these roundings.

Summary

National Assessment is designed to gather census-like data describing what groups of Americans know and can do. There is no attempt in this report to discuss whether these results show that the state of science education and knowledge in the United States is good or bad, or to make recommendations on the basis of these results. However, it is expected that citizens--including school administrators, curriculum specialists, science teachers, scientists, school board members, and legislators--will find National Assessment results in Science meaningful and useful in their understanding and their planning.

NUMBER OF EXERCISES AT DIFFERENT LEVELS OF SUCCESS

AGE 9

% correct	Objective			
	I	II	III	IV
95-99	o	●		
90-94	●●●oooooo	●oo	o	
85-89	●●●●●oooo	●oo		o
80-84	●●●●●oo	●		o
75-79	●●●●●oooooo	oo	●●	
70-74	●●●ooooo	●o	o	●
65-69	●ooo	●●oo		oo
60-64	●●ooooo	●o		o
55-59	●●●ooo	o		
50-54	●●●oo	●●●o		
45-49	●●oo	o		●
40-44	●●o		o	o
35-39	●●●ooooo	●	●	
30-34	●ooo		o	o
25-29	●	o	o	
20-24	oo		●●o	
15-19	●o	●o		
10-14	oo			o
5- 9	●			
0- 4				

● Released

o Not released

Each circle represents one exercise.

Figure 1-1

NUMBER OF EXERCISES AT DIFFERENT LEVELS OF SUCCESS*

AGE 13

% correct	Objective			
	I	II	III	IV
95-99	●●oo			
90-94	●ooo	●oo		●●oo
85-89	●●oo		o	
80-84	oo	●●		
75-79	●●ooooo	●o	●	
70-74	●oo	●ooo	●	
65-69	●o		●oo	
60-64	●●oooooo	●●●oo		
55-59	●●●oooooo	o	●	
50-54	●●ooooo	o		
45-49	●●oooooo	o	o	o
40-44	●oo	o		
35-39	●●●●ooo	●●		o
30-34	●●o			
25-29	●●●ooo	●		
20-24		o		o
15-19		o		o
10-14		o		
5- 9	o			●o
0- 4	o	●		

● Released

o Not released

Each circle represents one exercise.

Figure 1-2

*Nine exercises, not yet scored, are omitted from this chart.

NUMBER OF EXERCISES AT DIFFERENT LEVELS OF SUCCESS*

AGE 17

% correct	Objective			
	I	II	III	IV
95-99	●●oo			
90-94	●o		●	
85-89	●oo			
80-84	o	●		●
75-79	●oo			●
70-74	●ooooo	●o	●	
65-69	●●●●●o	●o		
60-64	●oooo	o		
55-59	●●●●●ooo	●o		
50-54	●●●●	●o		
45-49	●●●ooooo			
40-44	●oo	●		
35-39	●●o			
30-34	●●oo	●o	o	
25-29	●●ooooo	oo	●	
20-24	●oooo	oo		
15-19	●●ooooooo	●		●
10-14	ooo	●		o
5- 9	●●oo		o	o
0- 4	●●o			

● Released

o Not released

Each Circle represents one exercise.

Figue 1-3

*Thirteen exercises, not yet scored, are omitted from this chart.

NUMBER OF EXERCISES AT DIFFERENT LEVELS OF SUCCESS*

ADULT

% correct	Objective			
	I	II	III	IV
95-99	●oo	●		
90-94	●o	o		
85-89	●oooo	●		
80-84	ooooo	o		
75-79	●ooo			●
70-74	●●oo	●o		
65-69	●●oo			
60-64	●●●●●ooo	●		
55-59	●●●●oooo		●o	
50-54	●oooo	●o		
45-49	●●ooo	●	●	o
40-44	●●●●	o		
35-39	●●●ooo	●		
30-34	●oo	o	o	
25-29	●oo	●●o		●o
20-24	●●o	o		
15-19	●●oo	●		
10-14	●oooo	●	o	o
5- 9	ooo			
0- 4	●			

● Released

o Not released

Each circle represents one exercise.

Figure 1-4

*Ten exercises, not yet scored, are omitted from this chart

2.

AGE TO AGE COMPARISONS

In Science, knowledge, understanding, and skills were expected to increase from 9 to 13 to 17, but not necessarily from 17 to young adult. Figures 2-1 to 2-10, showing percentages of correct responses on overlapping exercises support this expectation. The percentage is always greater for 13s than for 9s, and for 17s than for 13s. On the majority of overlapping exercises, 13s and 17s do better than Adults but there are a number of exercises where Adults perform better than respondents of school age.

The content of the limited number of overlapping exercises for these ages may be examined on pages 31 to 45. For a few of the exercises it will be noted that there is some slight change in the wording or order of choices from one age to another. Such variations are noted on the exercise.

Table 2-1 summarizes comparisons of results for 17s and with Adults. Of the 58 exercises given to both 17s and Adults 38 are answered correctly by more 17s, and Adults do better than 17s on 20 others. Examination of the I-don't-know choices shows a rather consistent pattern:

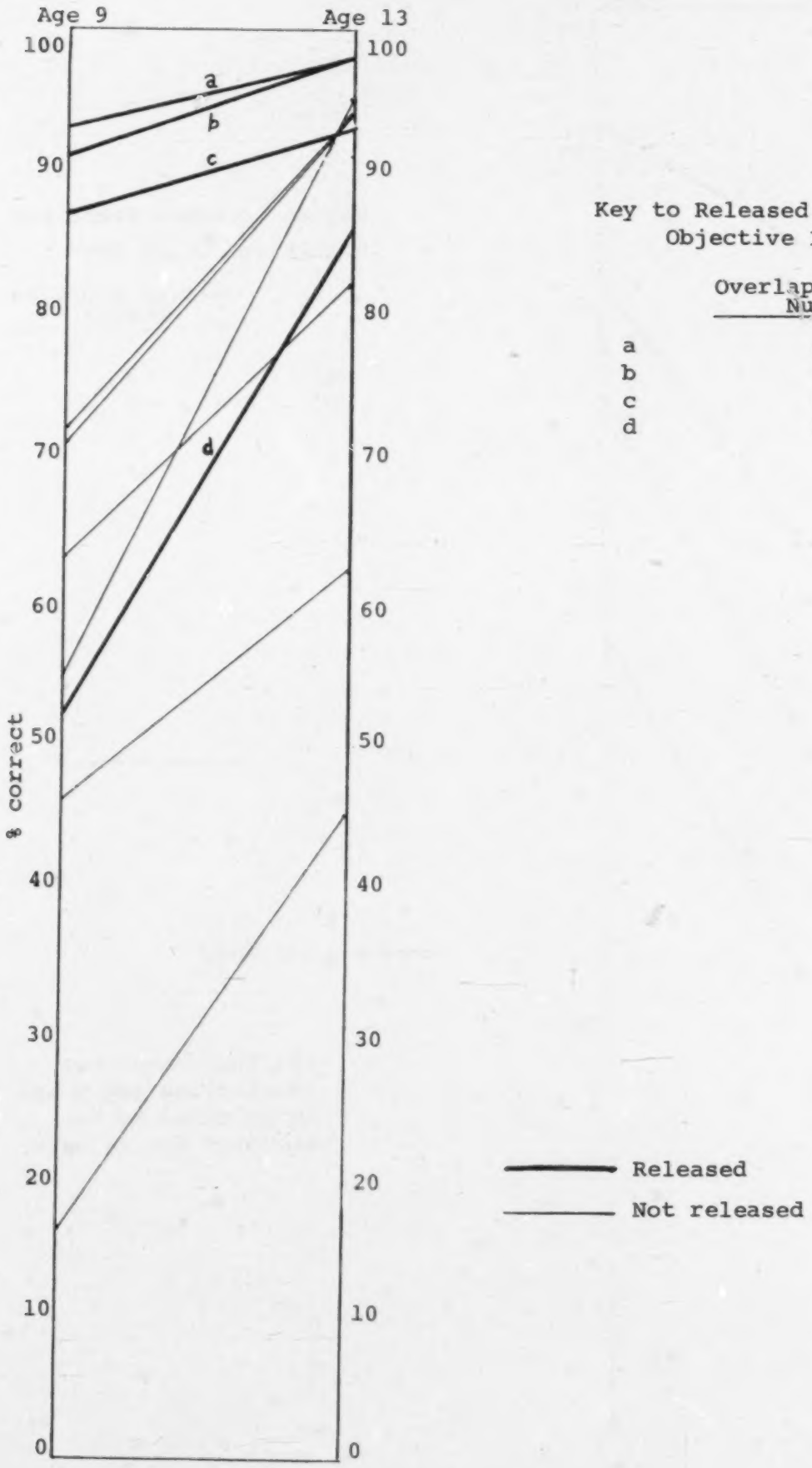
1. Adults use I-don't-know more often. (Indeed, 17s use this response more often than 13s, and 13s more than 9s.)

2. Adults usually make fewer wrong choices than 17s, thus showing less misinformation.

3. For most exercises, Adults make fewer right choices than do 17s, thus showing less information.

NAEP research found that adding the I-don't-know response tended to decrease the amount of guessing by respondents. The responses to the overlapping exercises suggest that (at least for certain exercises, most of which demand formal education) Adults are more willing than school age respondents to say I-don't-know. The 17s, on the other hand, use I-don't-know rather infrequently, and make many errors. The

LEVELS OF SUCCESS ON OVERLAPPING EXERCISES
OBJECTIVE I



Key to Released Exercises
Objective I

	Overlap Exercise Number
a	8
b	7
c	6
d	2

Figure 2-1

LEVELS OF SUCCESS ON OVERLAPPING EXERCISES
OBJECTIVES OTHER THAN I

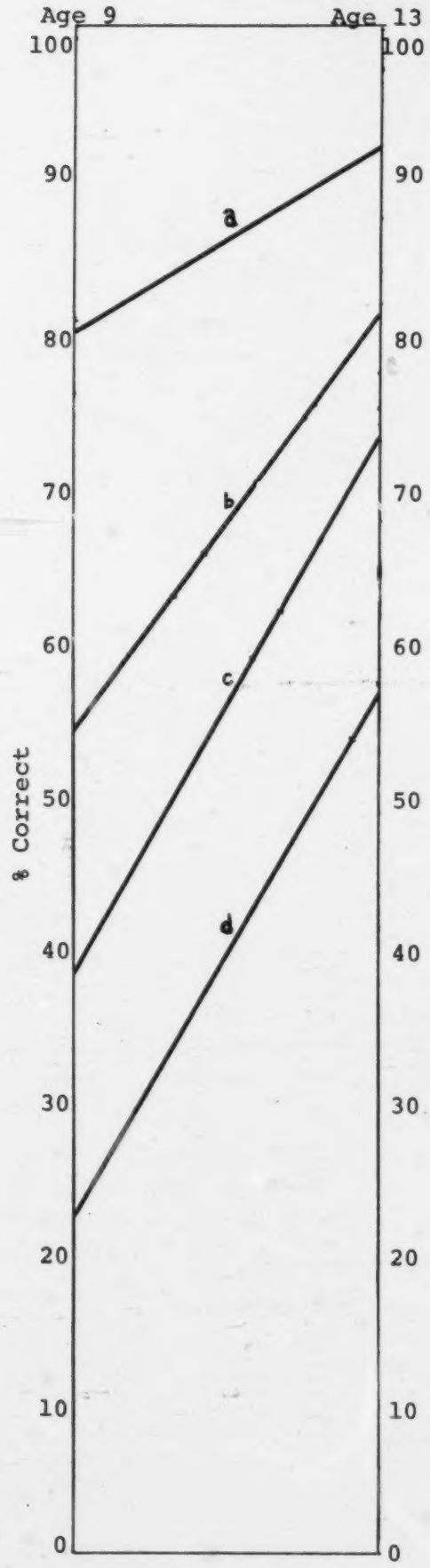


Figure 2-2

Key to Released Exercises
Objectives Other Than I

	Overlap Exercise Number
a	5
b	4
c	1
d	3

——— Released

All four exercises overlapping age 9 and 13 happened to be selected for release.

LEVELS OF SUCCESS ON OVERLAPPING EXERCISES
OBJECTIVE I

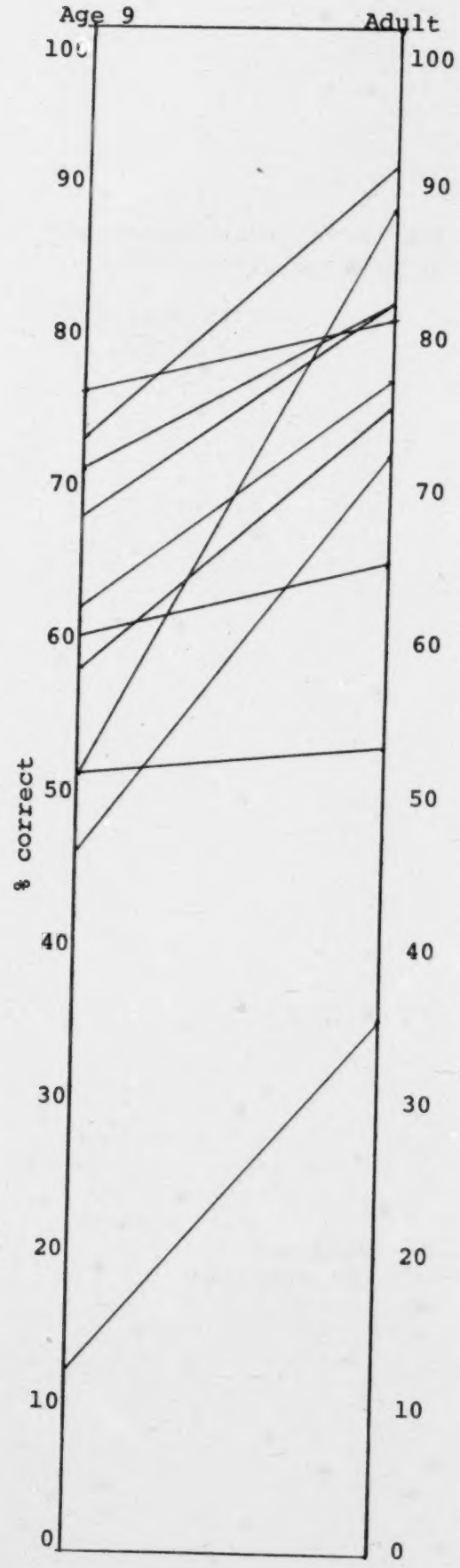
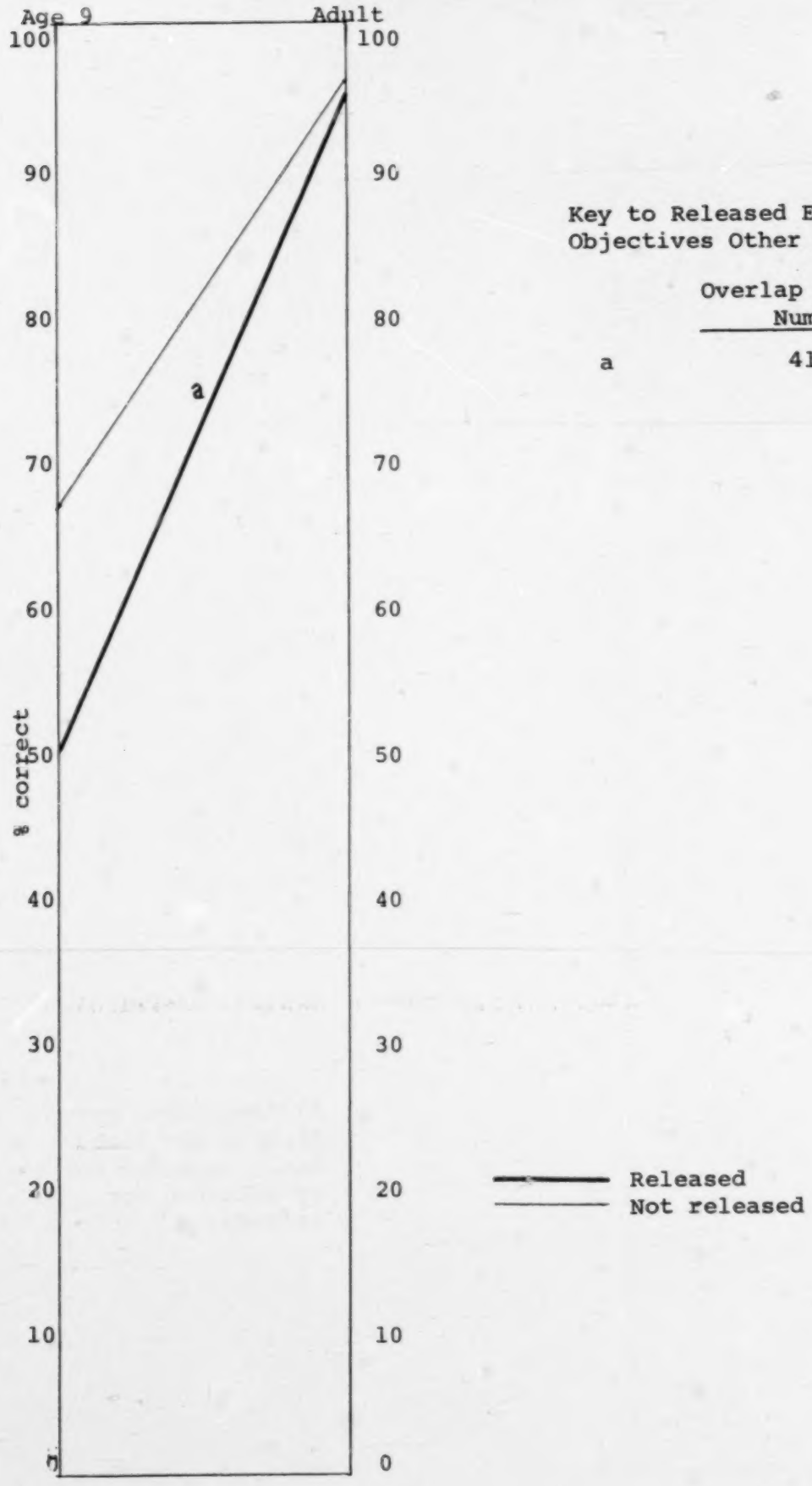


Figure 2-3

LEVELS OF SUCCESS ON OVERLAPPING EXERCISES
OBJECTIVES OTHER THAN I

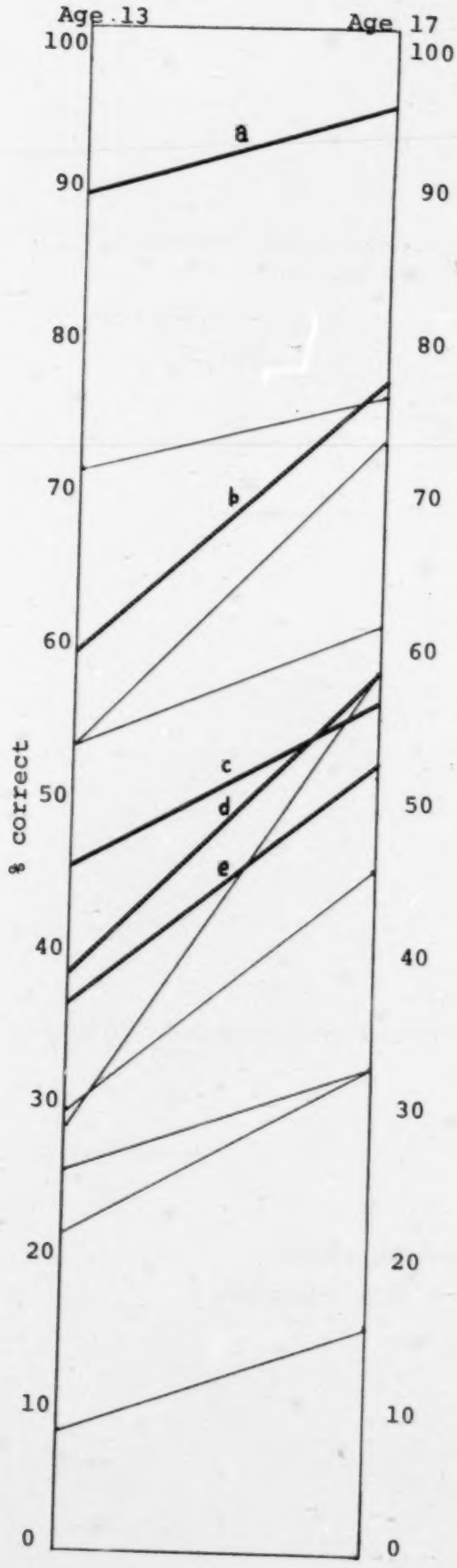


Key to Released Exercises
Objectives Other Than I

	Overlap Exercise Number
a	41

Figure 2-4

LEVELS OF SUCCESS ON OVERLAPPING EXERCISES
OBJECTIVE I

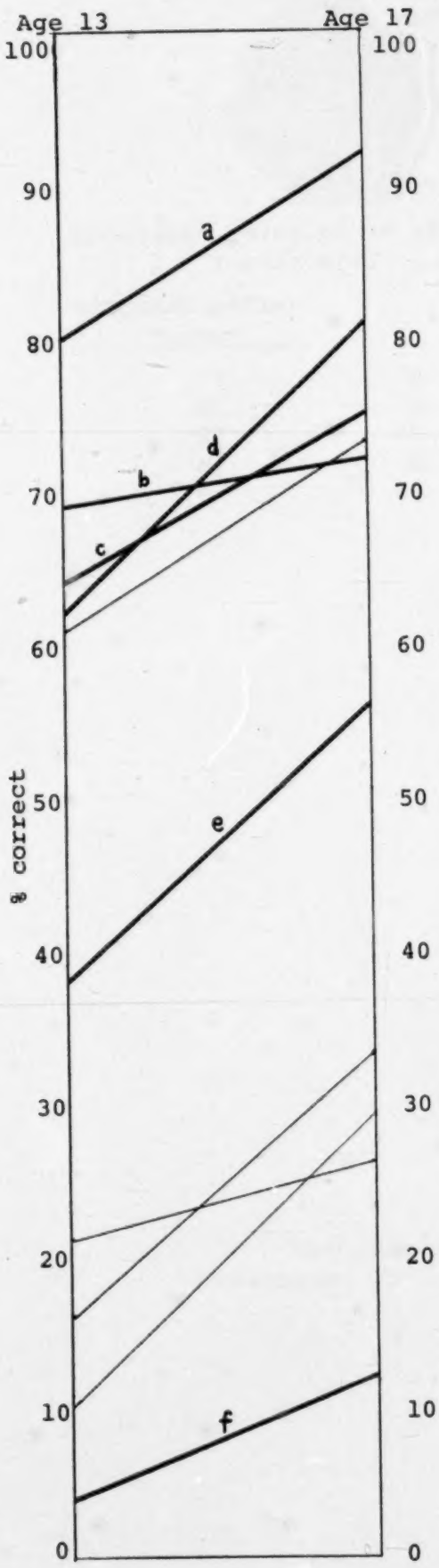


Key to Released Exercises
Objective I

	Overlap Exercise Number
a	13
b	18
c	12
d	10
e	9

Figure 2-5

LEVELS OF SUCCESS ON OVERLAPPING EXERCISES
OBJECTIVES OTHER THAN I



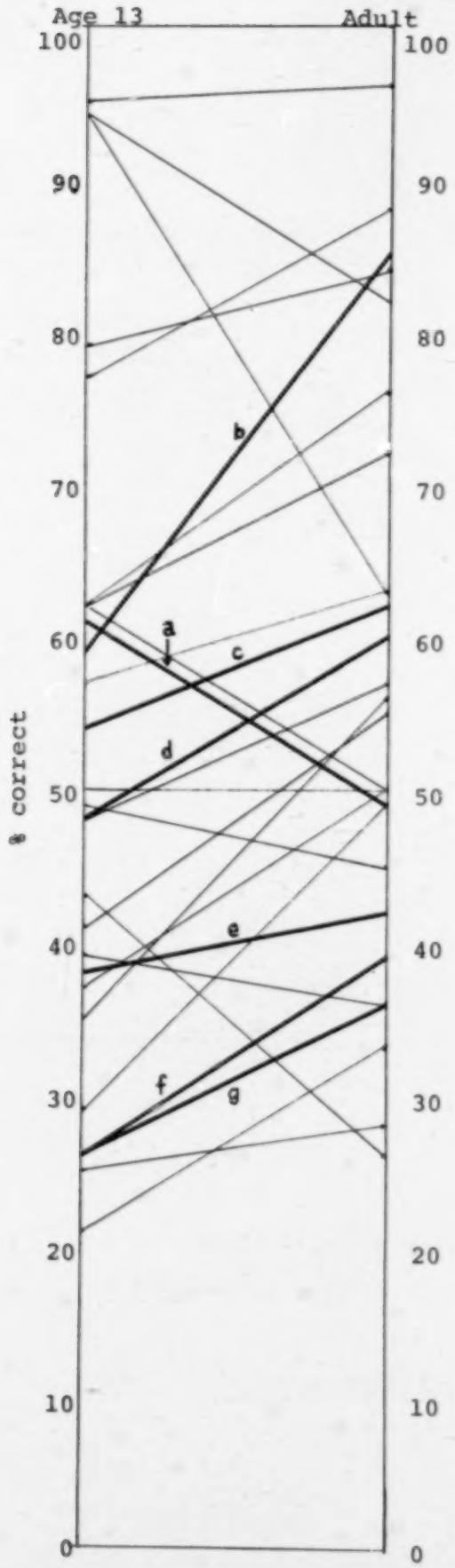
Key to Released Exercises
Objectives Other Than I

	Overlap Exercise Number
a	11
b	35
c	22
d	39
e	31
f	21

Released
Not released

Figure 2-6

LEVELS OF SUCCESS ON OVERLAPPING EXERCISES
OBJECTIVE I



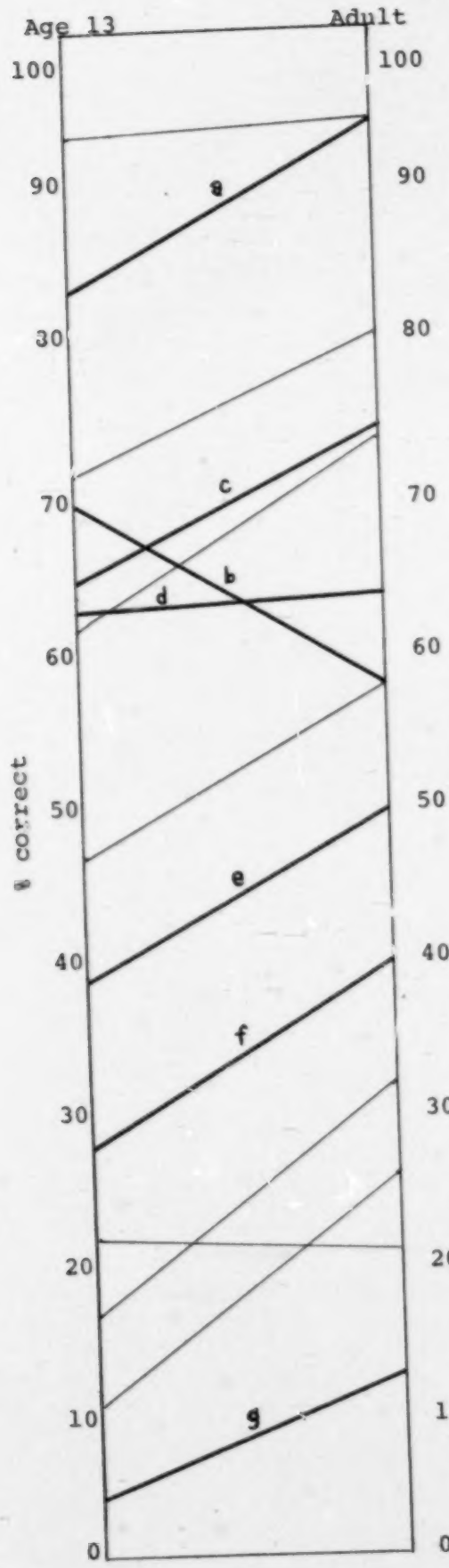
Key to Released Exercises
Objective I

	Overlap Exercise Number
a	49
b	18
c	47
d	43
e	48
f	42
g	46

Released
Not released

Figure 2-7

LEVELS OF SUCCESS ON OVERLAPPING EXERCISES
OBJECTIVES OTHER THAN I



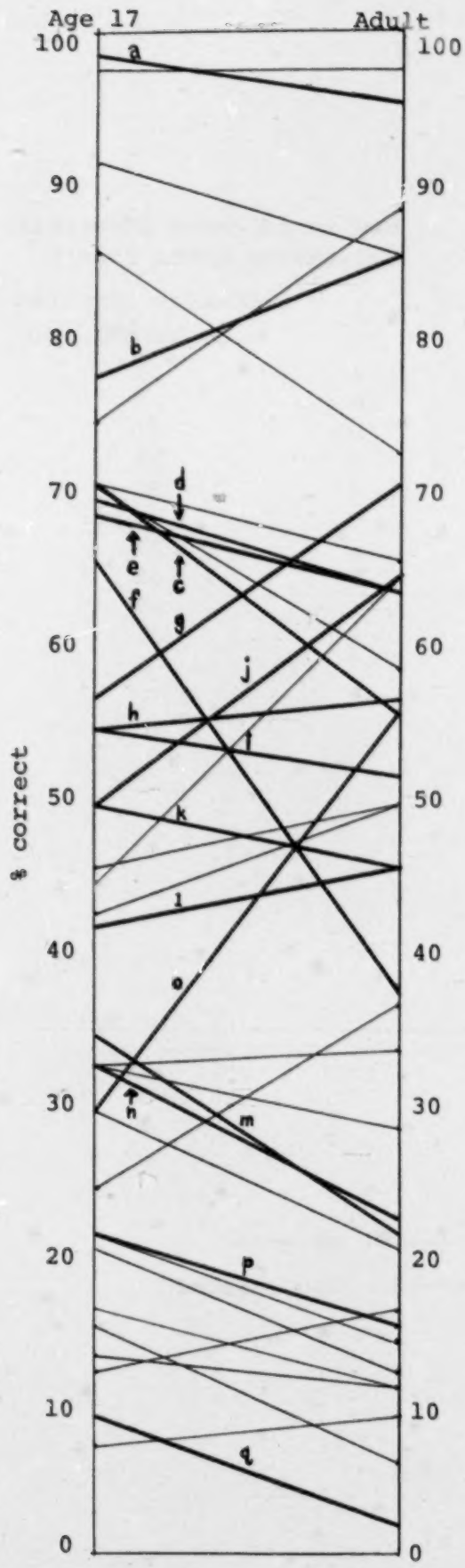
Key to Released Exercises
Objectives Other Than I

	Overlap Exercise Number
a	45
b	35
c	22
d	39
e	31
f	44
g	21

Released
Not released

Figure 2-8

LEVELS OF SUCCESS ON OVERLAPPING EXERCISES
OBJECTIVE I



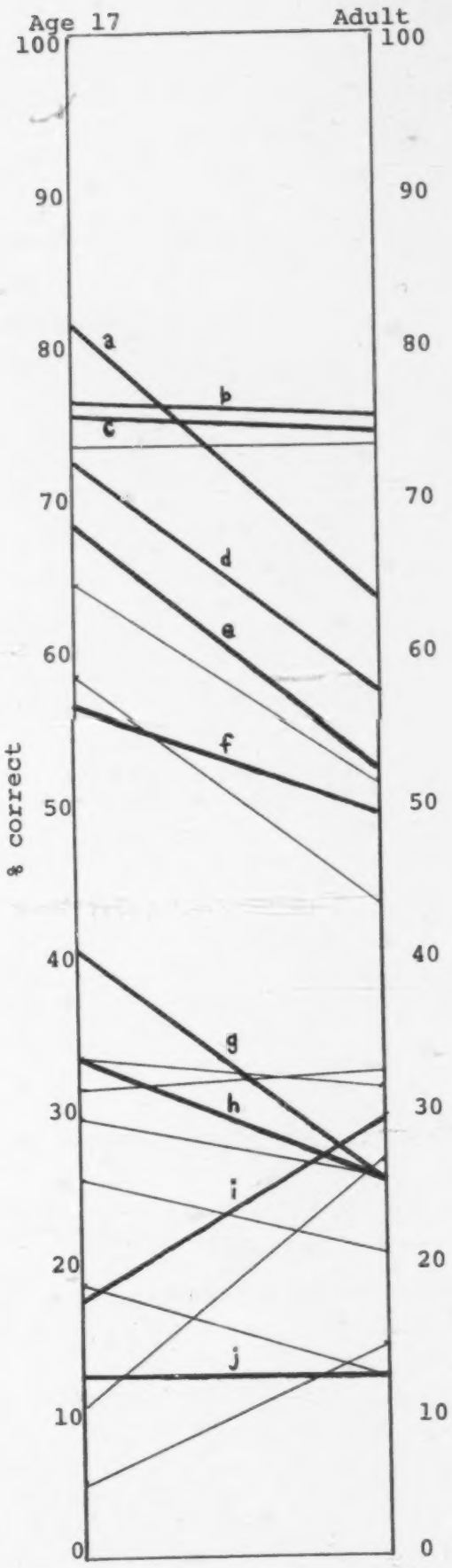
Key to Released Exercises
Objective I

	Overlap Exercise Number
a	25
b	18
c	36
d	28
e	27
f	40
g	16
h	20
i	24
j	15
k	26
l	19
m	34
n	33
o	14
p	29
q	30

Released
Not released

Figure 2-9

LEVELS OF SUCCESS ON OVERLAPPING EXERCISES
OBJECTIVES OTHER THAN I



Key to Released Exercises
Objectives Other Than I

	Overlap Exercise Number
a	39
b	23
c	22
d	35
e	38
f	31
g	37
h	32
i	17
j	21

Figure 2-10

TABLE 2-1

RELEASED AND UNRELEASED
OVERLAP EXERCISES COMPARED

17s more correct	38
Adults more correct	20
	58
17s more I-don't-know	8
Adults more I-don't-know	41
	49*
17s more wrong**	46
Adults more wrong**	12
	58

* There were no I-don't-know responses for nine exercises.

** Includes all responses except I-don't-know and the correct responses.

available data cannot tell us whether this is because the 17s don't want to say they don't know or whether they think their (incorrect) choice is correct.

Examination of the released exercises suggests that Adults do as well or better than 17s when asked questions which they may know from personal experience, whereas 17s do better on exercises which require formal education. Thus, Adults do better than 17s on two exercises which call for knowledge on human reproduction (14) and (19), and on an exercise about fuses (15)[3]. On the other hand, more 17s than Adults successfully chose the response "electrons" when asked, "An electric current in a copper wire involves mainly the movement of..." and given five alternatives (28). Similarly, 17s were more successful on (33): "Two light waves are traveling in a vacuum. The wave with the higher frequency will have the (shorter wave length)." While 32% of the 17s chose the correct response, 22% of the Adults chose it.

Frequently, choice of an incorrect response can provide further information. On the exercise below on ecology, for example, 20% of the 17s and 30% of the Adults were not able to apply a general principle to a specific case:

[3] The wording of this exercise differs somewhat for 17s and Adults.

Exercise 38

In a particular meadow there are many rabbits that eat the grass. There are also many hawks that eat the rabbits. Last year a disease broke out among the rabbits and a great number of them died. Which of the following probably then occurred?

Age 17	Adult		
4%	2%	O	*The grass died and the hawk population decreased.*
1	1	O	*The grass died and the hawk population increased.*
68	52	O	*The grass grew taller and the hawk population decreased.*
4	4	O	*The grass grew taller and the hawk population increased.*
20	30	O	*Neither the grass nor the hawks were affected by the death of the rabbits.*
2	10	O	*I don't know.*
1	1		*No response*
100%	100%		

On most of the overlapping exercises, the error choices are consistent from age to age. Although different percentages of 17s and Adults make errors, the two orders of "popularity" of the alternatives are usually similar. Exercise 32 illustrates this point.

Exercise 32

A particular cell is shaped like a cube. If all its linear dimensions were doubled, its volume would increase

Age 17	*Adult*		
5%	*4%*	*O*	*3 times.* (least popular of wrong choices)
22	*18*	*O*	*4 times.* (most popular of wrong choices)
15	*9*	*O*	*6 times.* (next to least popular of wrong choices)
33	*25*	●	*8 times.*
16	*16*	*O*	*16 times.* (next to most popular of wrong choices)
9	*28*	*O*	*I don't know.*
0	*1*		*No response*
100%	*101%*		

Clearly, the more popular wrong answers are popular at both ages. The correct answer ranks highest in both groups but that would not necessarily be the case in every difficult item.

Overlaps Between 13, 17, and Adult

Five exercises administered at all three of these ages were released. For each the percentage choosing the correct responses increases from 13 to 17. The differences between 17s and Adults are small and inconsistent in direction.

Adults ranked lowest on the exercise (35) written for Objective III, "Understand the investigative nature of science."

Exercise 35

Whenever scientists carefully measure any quantity many times, they expect that

Age 13	*Age 17*	*Adult*		
19%	*19%*	*25%*	*O*	*all of the measurements will be exactly the same.*
2	*2*	*1*	*O*	*only two of the measurements will be exactly the same.*
4	*3*	*2*	*O*	*all but one of the measurements will be exactly the same.*
69	*72*	*57*	*●*	*most of the measurements will be close but not exactly the same.*
6	*3*	*13*	*O*	*I don't know.*
0	*0*	*1*		*No response*
100%	*99%*	*99%*		

The correct response choice recognizes that measurement is inevitably imperfect, hence variation is to be expected. While more than half the respondents at each age answered correctly, the percent correct was only 57% among Adults compared to 69% of 13s and 72% of the 17s. At each age about one fourth of all the respondents chose the incorrect alternative, "all of the measurements will be exactly the same." This choice indicates a basic lack of understanding.

Adults and 17s were about equally successful on the information exercise (18): "Information about which one of the following is most important in predicting weather?" This is classed as requiring recall of facts. Seventy-seven percent or more of the 17s and Adults chose, "The movement and characteristics of air masses." Of the 13s, 59% correctly chose this response. The 13s often chose, "The daily extremes of temperature" (17%) or "The daily extremes of humidity" (12%). Fewer than 10% of the 17s or Adults chose either of these or any other answer.

There are three overlapping exercises of a "can you do it?" type. One requires ability to interpret data, and two require the ability to use scientific apparatus.

The first (39) presents data from five experiments in which two objects were weighed four times each. The four weights tabulated for each object differ from experiment to experiment. The respondent is asked to say which experiment "gives the strongest evidence" that object I weighs more than object II. The correct choice recognizes that a strongly consistent finding deserves greater trust.

Among Adults and 13s, about 60% chose the correct response; 17s did much better, 81% making the correct selection, and few saying I-don't-know. Fewer than 10% of any age group chose any one wrong alternative. Such scatter of choices suggests the presence of simple confusion or carelessness rather than poor understanding of science.

One of the overlapping apparatus exercises (22) used the equipment shown in Figure 2-2.

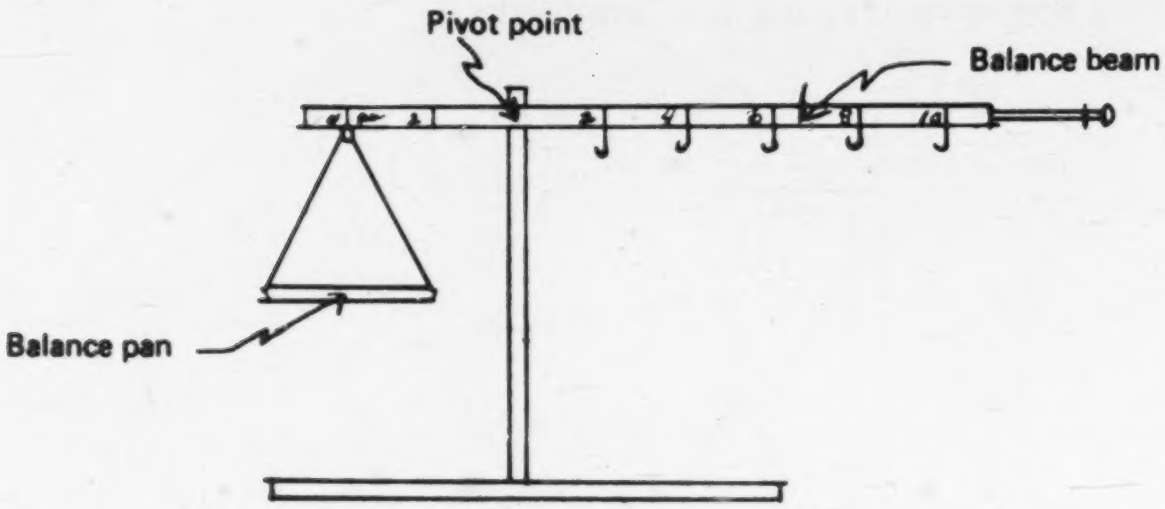


Figure 2-2

In addition to the apparatus pictured, the respondent was supplied with three 10-gram fishweights and instructed:

Place one weight in the balance pan. How many inches from the pivot point is the hook on which you must hang one weight to get balance?

He was given 20 minutes to respond to this and other questions involving the apparatus, and was given no assistance from the person administering the exercise on how to proceed.

The correct answer is that the second weight must be hung from the position labelled "4" to achieve balance. More than 60% of all ages correctly gave this answer. Adults and 17s are successful more often than are 13s.

Figure 2-3 shows the apparatus used for another exercise(31) where three age comparisons are possible.

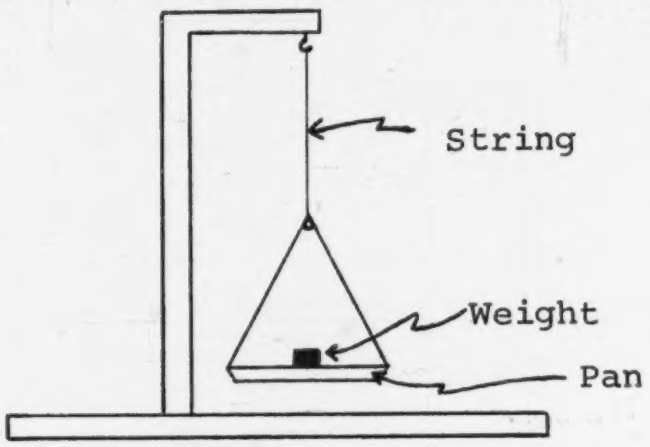


Figure 2-3

In addition to the pendulum, a clock or watch and several large nuts were available. The respondent was asked:

> How long does it take for the weight in the pan on the end of the string to swing back and forth ten times? _____seconds.

Again, respondents were given 20 minutes to find the answer to this and other questions involving the apparatus. Only 38% of the 13s gave a response between 11 and 15 seconds, which was judged correct. Adults (49%) and 17s (56%) did much better.

Overlaps between ages 9 and 13 (Overlap exercises 1 to 8).

These exercises are arranged by the order of size of observed difference between percentage of success at age 13 and age 9. The observed difference in percentage of success is noted in the heading for each exercise. It should be stressed that these differences are determined from the respondents that were sampled, and that the percentage difference would change somewhat if observations were made on other samples.

OVERLAP EXERCISE 1
35% difference in favor of age 13

(9: 6-3, 13: 2-1) (also 157 and 242)

Scientists would have most trouble testing which of the following?

Age 9	Age 13		
12 %	6 %	o	I have a fever.
6	2	o	I weigh 101 pounds.
14	4	o	I am 62 inches tall.
13	8	o	I can lift a 20-pound box.
38	73	●	My dog is better than your dog.
16	7	o	I don't know.
1	0		No response
100 %	100 %		

This order of alternatives was used at age 9; at age 13 the second and third choices were interchanged.

OVERLAP EXERCISE 2
34% difference in favor of age 13

(9: 5-4, 13: 6-2) (also 130 and 205)

The temperature that is thought most comfortable for a schoolroom is about

Age 9	Age 13		
15 %	1 %	o	40° Fahrenheit.
18	7	o	50° Fahrenheit.
52	86	●	70° Fahrenheit.
5	2	o	90° Fahrenheit.
3	0	o	100° Fahrenheit.
8	3	o	I don't know.
0	0		No response
101 %	99 %		

At age 13, the word "considered" was used in place of "thought."

OVERLAP EXERCISE 3
34% difference in favor of age 13

(9: 8-14, 13: 9-5) (also 158 and 244)

What is a scientific theory?

Age 9	Age 13		
4 %	1%	o	It uses arithmetic.
12	4	o	It describes a scientist.
27	19	o	It describes an experiment.
18	14	o	It tells all there is to know about something.
22	56	●	It explains why some things act the way they do.
18	5	o	I don't know.
0	0		No response
101%	99%		

OVERLAP EXERCISE 4
27% difference in favor of age 13

(9: 7-17A, 13: 9-13A) (also 150 and 231)

Weights of some Chemical Elements Found in a 100 pound Human	
Calcium	2 pounds
Carbon	18 pounds
Hydrogen	10 pounds
Oxygen	64 pounds
Phosphorus	14 ounces
Sodium	2 ounces
Sulfur	4 ounces

A. From the chart above, which of the following chemical elements is found in the SMALLEST amount in the body?

Age 9	Age 13		
14 %	3%	o	Calcium
5	3	o	Carbon
8	4	o	Hydrogen
54	81	●	Sodium
7	6	o	Sulfur
11	2	o	I don't know.
1	1		No response
100 %	100 %		

At age 13, "pounds" and "ounces" were abbreviated.
At age 13, "least" was used in place of smallest.

OVERLAP EXERCISE 5
12% difference in favor of age 13

(9: 7-17B, 13: 9-13B) (also 145 and 229)

Weights of some Chemical Elements Found in a 100 pound Human	
Calcium	2 pounds
Carbon	18 pounds
Hydrogen	10 pounds
Oxygen	64 pounds
Phosphorus	14 ounces
Sodium	2 ounces
Sulfur	4 ounces

B. From the chart above, which chemical element is found in the GREATEST amount in the body?

Age 9	Age 13		
2 %	2 %	o	Calcium
2	1	o	Carbon
4	1	o	Hydrogen
80	92	●	Oxygen
4	1	o	Phosphorus
7	1	o	I don't know.
2	0		No response
101 %	98 %		

At age 13, "pounds" and "ounces" were abbreviated.

OVERLAP EXERCISE 6
6% difference in favor of age 13

(9: 8-10, 13: 4-10) (also 106 and 203)

On a summer day, which of the following clouds is most likely to bring rain?

Age 9	Age 13		
2 %	1 %	o	Thin fluffy clouds
2	1	o	Red clouds at sunset
87	93	●	Thick dark-gray clouds
7	3	o	Clouds that look like white sheep
*	1	o	A few lines of clouds high in the sky
2	1	o	I don't know.
0	0		No response
100 %	100%		

This alternative not included at age 9.

OVERLAP EXERCISE 7
7% difference in favor of age 13

(9: 5-6, 13: 1-1) (also 103 and 202)

For which of the following reasons should you brush your teeth?

Age 9	Age 13		
2 %	0 %	o	To straighten your teeth
2	1	o	To make your teeth harder
1	0	o	To make your teeth sharper
2	0	o	To help your teeth grow larger
91	98	●	To help keep your teeth from decaying
1	0	o	I don't know.
0	0		No response
99%	99 %		

OVERLAP EXERCISE 8
6% difference in favor of age 13

(9: 5-13, 13: 7-15) (also 101 and 201)

Where does a human baby come from?

Age 9	Age 13		
1%	0%	O	The stork brings the baby.
92	98	●	The baby comes from its mother's body.
3	0	O	The doctor gives the baby to the mother.
1	0	O	The father buys the baby for the mother.
2	0	O	The hospital keeps many babies and the mother picks one out.
1	0	O	I don't know.
1	1		No response
101%	99%		

Overlaps between ages 13 and 17 (Overlap exercises 9 to 13).

OVERLAP EXERCISE 9
16% difference in favor of age 17

(13: 7-13, 17: 11-2) (also 223 and 321)

Which of these is characteristic of birds but of no other animals?

Age 13	Age 17		
37 %	27 %	O	Ability to fly
2	1	O	Ability to lay eggs
10	8	O	Tendency to migrate
36	52	●	Body covering of feathers
10	9	O	Regulated body temperature
4	3	O	I don't know.
1	1		No response
100 %	101 %		

OVERLAP EXERCISE 10
20% difference in favor of age 17

(13: 8-8, 17: 6-4) (also 222 and 314)

In terms of the theory of natural selection, what is the explanation of why giraffes have come to have such long necks?

Age 13	Age 17		
8 %	12 %	O	Stretching to get food in high trees has made their necks longer.
2	1	O	There is something inside of giraffes which keeps making longer necks.
12	6	O	Giraffe food contained vitamins which caused the vertebrae to lengthen.
28	13	O	Giraffe necks have gotten longer as time has gone on, but nobody has any idea why this is.
38	58	●	Giraffes born with the longest necks have been able to stay alive when food was scarce and have passed this trait on to their offspring.
12	10	O	I don't know.
0	0		No response
100 %	100 %		

At age 13, "the" was omitted from the third alternative.

OVERLAP EXERCISE 11
13% difference in favor of age 17

(13: 7-7, 17: 3-5) (also 241 and 349)

Skill in which of the following is most useful in scientific research?

Age 13	Age 17		
1 %	1 %	O	Music
4	1	O	Magic
1	1	O	Marketing
79	92	●	Mathematics
12	4	O	Manufacturing
3	1	O	I don't know.
0	0	O	No response
100 %	100 %		

OVERLAP EXERCISE 12
11% difference in favor of age 17

(13: 7-2, 17: 8-11) (also 218 and 317)

Mercury can be enclosed in glass to make a thermometer because mercury

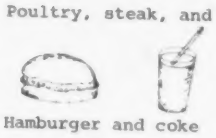
Age 13	Age 17		
11 %	8 %	O	is a metal.
8	5	O	is more dense than glass.
19	11	O	conducts heat better than glass.
*	9	O	has a higher specific heat than glass.
2	*		conducts electricity better than glass.
45	56	●	expands more than glass when both are heated together.
14	11	O	I don't know.
0	0		No response
99 %	100 %		

*A different fourth alternative was presented at the two ages.

OVERLAP EXERCISE 13
6% difference in favor of age 17

(13: 7-11, 17: 6-3) (also 204 and 302)

Which of the following would most closely represent a balanced meal?

Age 13	Age 17		
89 %	95 %	●	Steak, bread, carrots, and milk
1	0	O	Ice - cream soda and cake
5	3	O	Potatoes, oatmeal, bread, and bananas
3	1	O	Poultry, steak, and fish
			
1	1	O	Hamburger and coke
0	0	O	I don't know.
0	0		No response
99 %	100 %		

Overlaps between age 17 and Adult, including triple overlaps with age 13 (Overlap exercises 14 to 40).

OVERLAP EXERCISE 14
26% difference in favor of young adults

(17: 9-8, Adult: 7-22) (also 330 and 416)

On the average, in human females, the egg is released how many days after menstruation begins?

Age 17	Adult		
25 %	12 %	O	2 days
12	12	O	9 days
29	55	●	14 days
4	4	O	20 days
11	5	O	24 days
18	11	O	I don't know.
1	1		No response
100 %	100 %		

OVERLAP EXERCISE 15
15 % difference in favor of young adults

(17: 7-5, Adult: 1-13) (also 323 and 413)

The purpose of a fuse in an electric circuit is

Age 17	Adult		
13 %	8 %	O	to increase the current in the circuit.
14	7	O	to increase the voltage across the circuit.
*	5	O	to decrease the electrical resistance.
9	*		to decrease the resistance of the circuit.
*	64	●	to make the circuit safer.
49	*		to prevent possible damage to the circuit.
2	1	O	to raise the temperature of the wires in the circuit.
13	14	O	I don't know.
0	0	O	No response
100 %	99 %		

*Alternative not given at this age level.

The order of the alternatives at the Adult level may be seen in Exercise 413.

OVERLAP EXERCISE 16
14% difference in favor of young adults

(17: 10-2, Adult: 6-20) (also 316 and 406)

Which of the following acts as a stimulant to the heart?

Age 17	Adult		
56 %	70 %	●	Adrenaline
16	12	O	Alcohol
2	1	O	Aspirin
9	6	O	Barbiturates
6	3	O	Penicillin
10	6	O	I don't know.
0	2		No response
99 %	100 %		

OVERLAP EXERCISE 17
12% difference in favor of young adults

(17: 11-10, Adult: 10-1) (also 354 and 449)

(a) If you learn about a special television program dealing with a scientific topic, do you watch it?

Age 17	Adult		
17	29	●	Often
64	56	O	Sometimes
19	15	O	Never
1	0		No response
101%	100%		

OVERLAP EXERCISE 18
8% difference in favor of young adults

(13: 5-12, 17: 8-1, Adult: 2-12) (also 212, 305, and 403)

Information about which one of the following is most important in predicting weather?

Age 13	Age 17	Adult		
1%	1%	2%	O	The available supplies of water
12	9	3	O	The daily extremes of humidity
4	1	1	O	The daily extremes of wind speed
17	9	3	O	The daily extremes of temperature
59	77	85	●	The movement and characteristics of air masses
6	4	5	O	I don't know.
0	0	1		No response
99%	101%	100%		

For Adults, the first and fourth alternatives were interchanged.

OVERLAP EXERCISE 19
4% difference in favor of young adults

(17: 1-6, Adult: 1-17) (also 325 and 420)

What is the function of the placenta in a pregnant human female?

Age 17	Adult		
5%	3%	O	To push the baby out at birth
8	5	O	To keep the baby warm and moist
41	45	●	To carry nourishment to the baby
13	16	O	To cushion the baby against shocks
5	4	O	To keep the baby's body temperature constant
27	27	O	I don't know.
0	1		No response
99%	101%		

OVERLAP EXERCISE 20
2% difference in favor of young adults

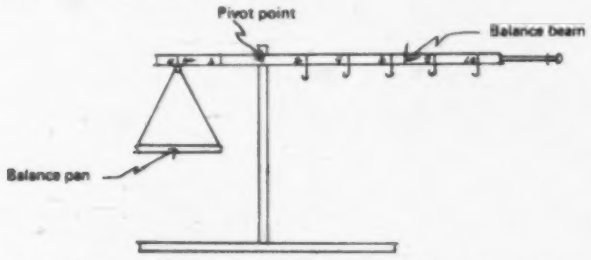
(17: 6-10, Adult: 3-16) (also 320 and 415)

A motor boat can travel 5 miles per hour on a still lake. If this boat travels downstream on a river that is flowing 5 miles per hour, how long will it take the boat to reach a bridge that is 10 miles downstream?

Age 17	Adult		
13%	11%	O	15 min..
16	11	O	30 min.
6	5	O	45 min.
54	56	●	60 min.
4	3	O	75 min.
8	14	O	I don't know.
0	1		No response
101%	101%		

OVERLAP EXERCISE 21
No difference

(13: 13-21a5, 17: 14-12a5, Adult: 10-21a5)
(also 240, 348, and 445)



The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

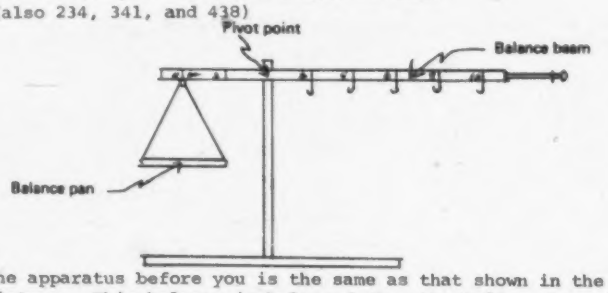
(The apparatus also included 10-gram fishweights, a centimeter ruler, and a block of wood 10 x 3 x 2 centimeters. Respondents were given 20 minutes to answer several related questions (e.g., see Exercise 22). The following question was preceded by others which required them to make measurements which would assist them in answering it.)

5. What is the density of the wood block? It is _____ grams per cubic centimeter. (An answer between .38 and .64 was scored correct.)

Age 13	Age 17	Adult	
4 %	12 %	12 %	Correct
70	63	29	Incorrect
25	25	59	No response
99 %	100 %	100 %	

OVERLAP EXERCISE 22
1% difference in favor of age 17

(13: 13-21a1, 17: 14-12a1, Adult: 10-21a1)
(also 234, 341, and 438)



The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

1. Place one weight in the balance pan. How many inches from the pivot point is the hook on which you must hang one weight to get balance? (4)

Age 13	Age 17	Adult	
64 %	75 %	74 %	Correct
34	22	20	Incorrect
2	2	6	No response
100 %	99 %	100 %	

The apparatus also included fishweights, one to place in the balance pan, and another to use to achieve balance. The respondent was given 20 minutes to find the answer to this and other questions involving the use of the apparatus (see Overlap Exercise 21).

OVERLAP EXERCISE 23
1% difference in favor of age 17

(17: 4-8, Adult: 2-22) (also 353 and 448)

United States scientists are ahead of scientists in other countries in every field of research.

Age 17	Adult		
17 %	19 %	O	I believe this statement.
76	75	●	I don't believe this statement.
7	5	O	I don't know.
0	1		No response
100 %	100 %		

OVERLAP EXERCISE 24
3% difference in favor of age 17

(17: 9-12, Adult: 4-20) (also 319 and 418)

A 5-pound rock is dropped from a cliff 500 feet high. The longer the rock falls, the greater is its

Age 17	Adult		
17 %	18 %	O	acceleration.
18	12	O	potential energy.
54	51	●	speed.
6	7	O	total energy.
3	3	O	volume.
3	8	O	I don't know.
0	1		No response
101 %	100 %		

OVERLAP EXERCISE 25
% difference in favor of age 17

(17: 5-3, Adult: 2-14) (also 301 and 401)

Which of the following groups of animals and plants would be found in a desert community?

Age 17	Adult		
0%	1%	O	Ground hogs, deer, oak, fern
0	1	O	Grizzly bears, buffaloes, fir, grass
0	0	O	Ducks, herons, water lilies, cattails
0	1	O	Starfish, sand dollars, kelp, plankton
98	95	●	Snakes, road runners, cactus, sagebrush
0	1	O	I don't know.
0	1		No response
98%	100%		

For Adults, the fourth and fifth alternatives were interchanged.

OVERLAP EXERCISE 26
4% difference in favor of age 17

(17: 1-3, Adult: 2-15) (also 322 and 421)

If a person who is a light eater has a tendency to be overweight, it is most likely due to

Age 17	Adult		
1%	1%	O	too much exercise.
3	3	O	a carefully balanced diet.
20	22	O	a tendency toward nervousness.
15	6	O	an excessive dosage of vitamins.
49	45	●	highly efficient utilization of food by the body.
12	20	O	I don't know.
0	2		No response
100%	99%		

OVERLAP EXERCISE 27
5% difference in favor of age 17

(17: 8-6, Adult: 3-12) (also 309 and 409)

The idea of natural selection is usually associated with the theory of evolution proposed by

Age 17	Adult		
68%	63%	●	Charles Darwin.
3	2	O	Edward Jenner.
2	1	O	Jean Lamarck.
7	3	O	Louis Pasteur.
1	0	O	Jonas Salk.
19	30	O	I don't know.
0	1		No response
100%	100%		

OVERLAP EXERCISE 28
6% difference in favor of age 17

(17: 5-5, Adult: 4-12) (also 308 and 408)

An electric current in a copper wire involves mainly the movement of

Age 17	Adult		
5%	2%	O	copper atoms.
10	4	O	copper molecules.
69	63	●	electrons.
3	1	O	neutrons.
2	1	O	protons.
11	28	O	I don't know.
0	1		No response
100%	100%		

OVERLAP EXERCISE 29
6% difference in favor of age 17

(17: 7-7, Adult: 1-14) (also 332 and 433)

Scientists can determine the age of certain rocks and their fossils by measuring

Age 17	Adult		
3 %	4 %	o	their specific gravities.
18	22	o	their crystalline structure.
22	17	o	the rate at which they have eroded.
18	10	o	the ratio of calcium to phosphorus in them.
21	15	●	the amounts of uranium and lead they contain.
18	32	o	I don't know.
0	0		No response
100 %	100 %		

OVERLAP EXERCISE 30
6% difference in favor of age 17

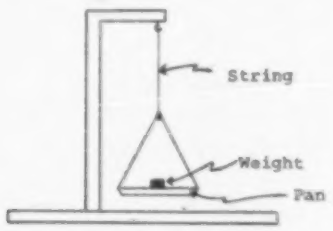
(17: 5-6, Adult: 8-18) (also 335 and 434)

Which of these has been used to obtain accurate estimates of the age of the oldest known rock strata?

Age 17	Adult		
25 %	22 %	o	Radiocarbon dating
9	3	●	Uranium - lead dating
2	3	o	Potassium - argon dating
11	5	o	Estimation of sedimentation rates
30	22	o	Correlation of age of fossils contained in the strata
15	43	o	I don't know.
0	1		No response
100 %	99 %		

OVERLAP EXERCISE 31
7% difference in favor of age 17

(13: 13-21c1, 17: 14-12c1, Adult: 10-21c1)
(also 237, 344, and 441)



The apparatus before you is a pendulum. You have a watch or clock also.

1. How long does it take for the weight in the pan on the end of the string to swing back and forth ten times? _____ seconds. (An answer between 11 and 15 seconds was scored correct.)

Age 13	Age 17	Adult	
38 %	56 %	49 %	Correct
56	41	39	Incorrect
6	3	12	No response
100 %	100 %	100 %	

OVERLAP EXERCISE 32
8% difference in favor of age 17

(17: 5-14, Adult: 4-14) (also 346 and 444)

A particular cell is shaped like a cube. If all its linear dimensions were doubled, its volume would increase

Age 17	Adult		
5 %	4 %	o	3 times.
22	18	o	4 times.
15	9	o	6 times.
33	25	●	8 times.
16	16	o	16 times.
9	28	o	I don't know.
0	1		No response
100 %	101 %		

OVERLAP EXERCISE 33
10% difference in favor of age 17

(17: 7-10, Adult: 6-19) (also 329 and 430)

Two light waves are traveling in a vacuum. The wave with the higher frequency will have the

Age 17	Adult		
14 %	2 %	O	higher speed.
3	15	O	lower speed.
23	13	O	longer wavelength.
32	22	●	shorter wavelength.
7	4	O	more nearly horizontal direction.
21	42	O	I don't know.
0	1		No response
100 %	99 %		

For Adults, the first and second alternatives were interchanged.

OVERLAP EXERCISE 34
13% difference in favor of age 17

(17: 3-6, Adult: 5-20) (also 328 and 431)

If the cells referred to were all in the same organism, in which of the following is the amount of DNA present stated correctly?

Age 17	Adult		
34 %	21 %	●	It would be identical in mature egg and sperm cells.
3	1	O	It would be identical in sperm cells and liver cells.
6	6	O	It would be identical in a mature egg cell and a brain cell.
3	1	O	It would be half as much in a thyroid cell as in a liver cell.
10	2	O	It would be half as much in the fertilized egg as in a thyroid gland cell.
45	67	O	I don't know.
0	1		No response
101 %	99 %		

OVERLAP EXERCISE 35
15% difference in favor of age 17

(13: 8-14, 17: 4-7, Adult: 6-17) (also 243, 350, and 446)

Whenever scientists carefully measure any quantity many times, they expect that

Age 13	Age 17	Adult		
19 %	19 %	25 %	O	all of the measurements will be exactly the same.
2	2	1	O	only two of the measurements will be exactly the same.
4	3	2	O	all but one of the measurements will be exactly the same.
69	72	57	●	most of the measurements will be close but not exactly the same.
6	3	13	O	I don't know.
0	0	1		No response
100 %	99 %	99 %		

OVERLAP EXERCISE 36
15% difference in favor of age 17

(17: 6-16, Adult: 3-7) (also 306 and 417)

All of the following help to increase the total amount of food available to the human race EXCEPT

Age 17	Adult		
2 %	2 %	O	irrigating crops.
12	12	O	developing hybrids.
2	2	O	improving fertilizers.
70	55	●	outlawing the use of insecticides.
10	17	O	controlling the growth of undesirable plants.
4	10	O	I don't know.
0	1		No response
100 %	99 %		

OVERLAP EXERCISE 37
15% difference in favor of age 17

(17: 3-4, Adult: 8-15) (also 345 and 443)

A student made the following statement, "Some carbon atoms in the bread that I ate last night might have once been part of a dinosaur's body."
Which of the following is the best appraisal of the student's statement? This statement

Age 17	Adult		
6 %	3 %	O	contradicts the law of conservation of matter.
2	5	O	is ridiculous because dinosaurs lived so long ago.
40	25	●	could be true because atoms are rarely created or destroyed.
24	33	O	could be true only if the bread was grown in soil containing dinosaur fossils.
15	7	O	could not possibly be true because dinosaurs were animals but wheat is a plant.
11	25	O	I don't know.
0	1		No response
98 %	99 %		

For Adults, the third and fourth alternatives were interchanged.

OVERLAP EXERCISE 38
16% difference in favor of age 17

(17: 5-8, Adult: 3-10) (also 342 and 440)

In a particular meadow there are many rabbits that eat the grass. There are also many hawks that eat the rabbits. Last year a disease broke out among the rabbits and a great number of them died. Which of the following probably then occurred?

Age 17	Adult		
4 %	2 %	O	The grass died and the hawk population decreased.
1	1	O	The grass died and the hawk population increased.
68	52	●	The grass grew taller and the hawk population decreased.
4	4	O	The grass grew taller and the hawk population increased.
20	30	O	Neither the grass nor the hawks were affected by the death of the rabbits.
2	10	O	I don't know.
1	1		No response
100 %	100 %		

OVERLAP EXERCISE 39
18% difference in favor of age 17

(13: 7-8, 17: 1-1, Adult: 1-7) (also 235, 340, and 439)

In each of five experiments, two objects were weighed four times each. Which experiment gives the strongest evidence that object I weighs more than object II?

Age 13	Age 17	Adult			Object I	Object II
62 %	81 %	63 %	●	Experiment A	80 lb.	70 lb.
					81 lb.	69 lb.
					80 lb.	71 lb.
					82 lb.	70 lb.
9	4	7	O	Experiment B	69 lb.	81 lb.
					71 lb.	82 lb.
					70 lb.	80 lb.
					70 lb.	80 lb.
3	1	2	O	Experiment C	70 lb.	80 lb.
					75 lb.	75 lb.
					77 lb.	73 lb.
					80 lb.	70 lb.
3	1	2	O	Experiment D	80 lb.	70 lb.
					75 lb.	75 lb.
					73 lb.	77 lb.
					70 lb.	80 lb.
9	5	9	O	Experiment E	80 lb.	77 lb.
					79 lb.	76 lb.
					78 lb.	75 lb.
					77 lb.	74 lb.
12	5	15	O	I don't know.		
2	2	3		No response		
100 %	99 %	101				

OVERLAP EXERCISE 40
23% difference in favor of age 17

(17: 6-1, Adult: 10-18) (also 311 and 426)

The solid, liquid, and gaseous states of water differ in which of the following ways?

Age 17	Adult		
3 %	1 %	O	The number of protons per molecule
4	1	O	The number of electrons per molecule
4	3	O	The net charge on the individual molecules
5	2	O	The number of neutrons per individual molecule
65	37	●	The average speed with which the molecules are moving.
20	53	O	I don't know.
0	2		No response
101 %	99 %		

Overlaps between ages 9 or 13 and Adult (Overlap exercises 41 to 49).

OVERLAP EXERCISE 41
45% difference in favor of young adults

(9:2-10, Adult: 7-12) (also 152 and 435)

Why do very few people get smallpox in the United States today?

Age 9	Adult		
12 %	1 %	O	The weather conditions have changed.
50	95	●	Most people get smallpox vaccinations.
6	0	O	People move more often than they used to.
4	0	O	People drink more milk today than ever before.
17	1	O	All the germs that cause smallpox have been killed.
11	1	O	I don't know.
0	1		No response
100 %	99 %		

OVERLAP EXERCISE 42
13% difference in favor of young adults

(13: 9-7, Adult: 6-11) (also 228 and 425)

A fossil of an ocean fish was found in a rock outcrop on a mountain. This probably means that

Age 13	Adult		
3 %	4 %	O	fish once lived on the mountain.
3	1	O	the relative humidity was once very high.
26	39	●	the mountain was raised up after the fish died.
10	4	O	fish used to be amphibians like toads and frogs.
53	41	O	the fossil fish was probably carried to the mountain by a great flood.
5	10	O	I don't know.
0	1		No response
100 %	100 %		

OVERLAP EXERCISE 43
12% difference in favor of young adults

(13: 6-10, Adult: 9-19) (also 217 and 412)

Most of the chemical energy of the gasoline burned in a car is not used to move the car but is changed into

Age 13	Adult		
24 %	14 %	O	electricity.
48	60	●	heat.
1	0	O	light.
8	4	O	magnetism.
3	4	O	sound.
16	16	O	I don't know.
0	2		No response
100 %	100 %		

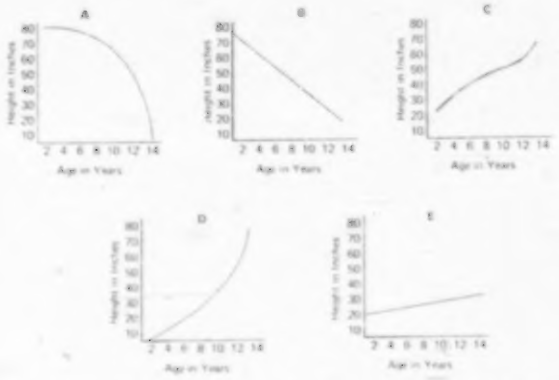
For Adults, "converted" was used instead of "changed".

OVERLAP EXERCISE 44
12% difference in favor of young adults

(13: 2-9, Adult: 4-8) (also 239 and 442)

Which of the following graphs could show the average height in inches of a group of children growing at a normal rate plotted against their age in years?

Age 13	Adult		
16 %	6 %	O	A
14	9	O	B
27	39	●	C
16	18	O	D
10	9	O	E
16	16	O	I don't know.
0	3		No response
99 %	100 %		



The curve of Graph C is slightly different at the Adult level, but conveys the same idea.

OVERLAP EXERCISE 45
11% difference in favor of young adults

(13: 4-15, Adult: 5-19) (also 230 and 436)

A man notices that the paint on one side of his house is not lasting as well as the paint on the other sides. Which of the following is the most likely cause?

Age 13	Adult		
5 %	1 %	O	Termites
8	2	O	Cosmic rays
83	94	●	Wind or sun
0	0	O	Fallout from atom bombs
1	0	O	Sonic booms from low-flying jets
3	1	O	I don't know.
0	1		No response
100 %	99 %		

OVERLAP EXERCISE 46
10% difference in favor of young adults

(13: 7-6, Adult: 7-11) (also 227 and 427)

In mammals, which of the following is the center of memory and intelligence?

Age 13	Adult		
21 %	27 %	O	Cerebellum
26	36	●	Cerebrum
11	6	O	Medulla
10	4	O	Optic nerve
7	2	O	Spinal cord
25	24	O	I don't know.
0	1		No response
100 %	100 %		

OVERLAP EXERCISE 47
8% difference in favor of young adults

(13: 5-2, Adult: 8-19) (also 215 and 410)

Flower seeds develop from

Age 13	Adult		
2 %	1 %	O	leaves.
54	62	●	ovules.
15	10	O	petals.
15	8	O	roots.
6	4	O	stems.
9	12	O	I don't know.
0	2		No response
101 %	99 %		

OVERLAP EXERCISE 48
4% difference in favor of young adults

(13: 7-14, Adult: 2-20) (also 221 and 422)

Most caves are formed by the action of underground water on

Age 13	Adult		
10%	9%	O	granite.
38	42	●	limestone.
4	1	O	pumice.
23	16	O	sandstone.
6	4	O	shale.
18	27	O	I don't know.
0	1		No response
99%	100%		

OVERLAP EXERCISE 49
12% difference in favor of age 13

(13: 3-13, Adult: 9-20) (also 211 and 419)

Which of the following is true of hot water as compared with cold water?

Age 13	Adult		
9%	6%	O	It is denser.
3	2	O	It is easier to see through.
61	49	●	Its molecules are moving faster.
9	4	O	It has more free oxygen dissolved in it.
6	5	O	It has more free hydrogen dissolved in it.
12	32	O	I don't know.
0	1		No response
100%	99%		

RESULTS FOR ALL RELEASED EXERCISES FOR EACH AGE

In the pages to follow, exercises for each age level are discussed. At each age level, it is useful to think of exercises in three broad classes: those answered correctly by most respondents (67-100%), those answered correctly by a good many respondents (34-66%), and those answered correctly by rather few (0-33%).

Individuals taking part in the assessment are only a sample of Americans of their age. Percentage values reported below are subject to sampling error as well as some systematic errors. Many precautions were taken to minimize systematic errors, and the assessment sample size brings random error to acceptable levels. However, the percentage values reported here must be understood as <u>estimates</u> of what true value would be found if it were possible to assess all U.S. residents of a given age level.

The majority of exercises discussed below are of the multiple-choice type. Other exercises, usually related to Objective II, require ability to manipulate scientific apparatus and conduct small experiments.

Still others require the student to write a correct response in several words or a sentence. If an exercise is NOT of the multiple-choice type it will be mentioned when it's discussed.

Age 9

Objective I. Know the Fundamental Facts and Principles of Science

General Summary

The facts and principles of science known to most 9-year-olds evidently have to do with simple properties of matter (iron cannot be burned in an ordinary fire) or simple explanations of commonplace phenomena (day and night occur because the earth rotates, soaking with water is the surest way to put out a wood fire).

A good many 9-year-olds know more complex facts. Exercises where success ranged from 34% to 66% referred to scientific hypotheses (most scientists think the center of the earth is very hot), distinctions which may be confusing (the sun is a star not a planet), chemical reactions (a different substance is formed when a candle burns), electrical polarity (how to connect a flashlight bulb), and everyday living (how to dress for a 45-degree day, 70 degrees is a comfortable temperature, houseflies often carry disease).

Questions which rather few 9-year-olds answered correctly seemed to be exercises which offered false but plausible alternatives. Thus, a majority thought that coal is formed from lava rather than from dead plants. A majority became confused when numerical data (such as temperatures) were introduced. Most thought that mixing two portions of liquid of different temperatures would result in an overall temperature increase rather than a temperature somewhere between the temperatures of the original portions. It was difficult for them to say whether water, air, sawdust or mercury is heaviest, assuming equal volumes, perhaps because the substance mercury is unfamiliar. Half of the 9-year-olds selected water as the heaviest substance.

When given National Assessment exercises, most 9-year-olds responded correctly to exercises on the following:

101. A human baby comes from its mother's body (92%).

102. A stick needs to be dry in order to burn (92%).

103. You brush your teeth to keep them from decaying (91%).

104. Iron cannot be burned in an ordinary fire (89%).

105. Bees get their food (nectar) from flowers (88%).

106. Thick dark clouds generally bring rain (87%).

107. Soaking with water is a good way to put out a wood fire (87%).

108. Protein is important to the building of muscle (85%).

109. Nearly all rocks are solid (84%).

110. Map reading: An island completely surrounded by water (83%).

111. Day and night occur because the earth rotates (81%).

112. Acid should be handled carefully (80%).

113. Pine trees stay green during the winter (80%).

114. Alligators are found in swamps (79%).

115. To see something, light must reach one's eyes (79%).

116. One kind of plant which does not have green leaves is a mushroom (77%).

117. A burning candle when sealed in a glass jar goes out (75%).

118. Animals hide from other predatory animals in several ways (74%).

119. Lifting a 20-pound weight 2 feet is more work than lifting the same weight 1 foot, or a 10-pound weight 2 feet (73%).

120. A moving block striking a motionless block will cause the latter to move away from the first block (70%).

121. The sun is seen only during daytime because the earth is turning (70%).

122. Honeybees are more beneficial to man than are lice, locusts, or termites (69%).

A good many 9-year-olds (34-66%) responded correctly to exercises which required them to know:

123. Scientists study fossils to learn what animals lived long ago (62%).

124. How to properly connect a bulb to a flashlight battery (61%).

125. Most land plants get most of their water directly from the soil (59%).

126. Most scientists think the center of the earth is very hot (58%).

127. That the sun and a penny are both made of atoms (57%).

128. The sun is a star (52%).

129. How to dress properly for sunny 45-degree weather (52%).

130. A school room is most comfortable at about 70 degrees F (52%).

131. Cactus plants survive on the desert because they lose little water through their leaves (49%).

132. A different substance is formed from a candle when it burns (46%).

133. In a scientific study all conditions other than those being purposely manipulated should be kept constant (44%).

134. Houseflies can spread serious human disease (44%).

135. A rock broken into three pieces raises the water in a container as much as the whole rock did (36%).

136. All matter takes up space (36%).

137. A quart of mercury weighs more than a quart of air, sawdust, or water (35%); 48% of those making a choice selected water as the heaviest of the listed materials.

138. After a cold front passes, it is common to have clearing skies (34%).

When given National Assessment exercises, rather few 9-year-olds responded correctly to exercises on the following:

139. Rock cannot indefinitely be broken into smaller and smaller pieces and still be rock (27%).

140. Coal is formed from dead plants (15%). Over half of the respondents (56%) chose "lava from volcanoes" as the source of coal.

141. The mixing of equal quantities of water at 70 degrees F and water at 50 degrees F yields a mixture which is at 60 degrees F (7%). Over two-thirds (69%) of the respondents thought that the resulting would have a temperature of 120 degrees F.

EXERCISE 101

(9: 5-13) (overlaps Exercise 201)

Where does a human baby come from?

Age 9		
1 %	O	The stork brings the baby.
92	●	The baby comes from its mother's body.
3	O	The doctor gives the baby to the mother.
1	O	The father buys the baby for the mother.
2	O	The hospital keeps many babies and the mother picks one out.
1	O	I don't know.
! 1		No response
101 %		

Not administered to the in-school sample in one Southeastern county and one Southeastern city at the request of state or local authorities.

EXERCISE 102

(9: 3-6)

If you want to burn a stick, you should

Age 9		
2 %	O	wet it.
1	O	float it in a pond.
92	●	see that it is dry.
4	O	cover it with dirt.
1	O	I don't know.
0		No response
100 %		

EXERCISE 103

(9: 5-6) (overlaps Exercise 202)

For which of the following reasons should you brush your teeth?

Age 9		
2 %	O	To straighten your teeth
2	O	To make your teeth harder
1	O	To make your teeth sharper
2	O	To help your teeth grow larger
91	●	To help keep your teeth from decaying
1	O	I don't know.
0		No response
99 %		

EXERCISE 104

(9: 6-13)

All of the following can be burned in a fireplace EXCEPT

Age 9		
89%	●	iron.
2	O	leaves.
2	O	paper.
6	O	wood.
0	O	I don't know.
1		No response
100 %		

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EXERCISE 105

(9: 8-15)

Bees go to flowers in order to

Age 9		
3 %	o	see the flowers.
6	o	smell the flowers.
88	•	get nectar for food.
2	o	hide from the wind and rain.
1	o	I don't know.
0		No response
100 %		

EXERCISE 106

(9: 8-10) (similar to Exercise 203)

On a summer day, which of the following clouds is most likely to bring rain?

Age 9		
2 %	o	Thin fluffy clouds
2	o	Red clouds at sunset
87	•	Thick dark-gray clouds
7	o	Clouds that look like white sheep
2	o	I don't know.
0		No response
100 %		

EXERCISE 107

(9: 8-6)

The surest way to put out a fire of wood sticks is to

Age 9		
4 %	o	fan the fire.
87	•	soak the wood with water.
4	o	put some dry grass on the fire.
3	o	put some smaller sticks on the fire.
2	o	I don't know.
0		No response
100 %		

EXERCISE 108

(9: 2-2)

Which of the following is most important in building muscle?

Age 9		
4 %	o	Fat
85	•	Protein
2	o	Salt
2	o	Starch
2	o	Sugar
6	o	I don't know.
0		No response
101 %		

EXERCISE 109

(9: 1-6)

Nearly all rocks on the Earth's surface are

Age 9		
5%	O	gas.
6	O	liquid.
84	●	solid.
4	O	I don't know.
0		No response
99%		

EXERCISE 110

(9: 7-2)

Which of the letters on the map above is on an island?

Age 9		
7%	O	A
4	O	B
1	O	C
83	●	D
3	O	I don't know.
2		No response
100%		

EXERCISE 111

(9: 7-9)

One reason that there is day and night on Earth is that the

Age 9		
8%	O	Sun turns.
4	O	Moon turns.
81	●	Earth turns.
6	O	Sun gets dark at night.
1	O	I don't know.
0		No response
100%		

EXERCISE 112

(9: 3-11)

If you see a bottle labeled ACID, you should

Age 9		
1%	O	add soap to it.
3	O	put it in a box.
80	●	be careful with it.
3	O	put it under water.
10	O	pour it down the sink.
2	O	I don't know.
0		No response
99%		

EXERCISE 113

(9: 7-8)

Which of these trees stays green in the United States during the winter?

Age 9		
4%	O	Apple
7	O	Elm
6	O	Maple
80	●	Pine
4	O	I don't know.
0		No response
101 %		

EXERCISE 114

(9: 4-13)

One is most likely to find an alligator in

Age 9		
79%	●	a swamp.
3	O	the woods.
3	O	the desert.
13	O	a cold lake.
1	O	I don't know.
0		No response
99%		

EXERCISE 115

(9: 6-12)

For you to see something, what must reach your eyes?

Age 9		
79 %	●	Light
3	O	Smoke
3	O	Sound
13	O	Nothing
2	O	I don't know.
1		No response
101%		

EXERCISE 116

(9: 3-7)

Which of these plants does NOT have green leaves?

Age 9		
9%	O	A dandelion
7	O	Grass
77	●	A mushroom
5	O	A willow tree
2	O	I don't know.
1		No response
101 %		

EXERCISE 117

(9: 5-2)

If a lid is put on a jar in which a candle is burning, what happens?

Age 9		
3%	O	The candle breaks.
1	O	The candle gets longer.
16	O	The candle burns faster.
75	●	The candle flame goes out.
4	O	I don't know.
0		No response
99%		

EXERCISE 118

(9: 10-22)

How do some animals hide from other animals?

Points	Percentage Receiving X Points
1	18
2	23
3	29
4	17
5 or more	5
No response	7
	99%

To be counted as responding successfully, a student must have received at least 2 points.

% successful 74%

(continued on next page)

EXERCISE 118
(continued)

(9: 10-22)

Points were given according to the method below:

2 points for mentioning protective coloration

2 points for mentioning "protective shapes," including behavior such as that of an opossum

4 points for mentioning locations for hiding

(a point each for any 4 reasonable ones)

(1 point for location regardless of adjective preceding it)

(1 point for "getting behind something" if this appears alone)

(1 point for a given location regardless of preposition preceding location; e.g.,

in bush
behind bush
under bush
beside bush

is given one point in total

trees
woods
bushes
shrubs

would each get one point even though similar

1 point for "flight" regardless of term or terms such as "running, flying, leaping, swimming" used

No points for: "killing other animals"

No extra points for examples of animals that hide in a certain way

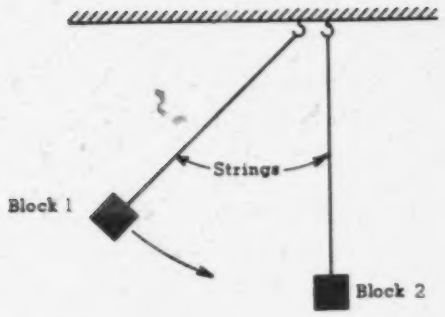
EXERCISE 119

(9: 1-15)

Which of these tasks would take the most work?

Age 9		
3%	O	Lifting a 10-pound weight 1 foot
15	O	Lifting a 20-pound weight 1 foot
4	O	Lifting a 10-pound weight 2 feet
73	●	Lifting a 20-pound weight 2 feet
4	O	I don't know.
0		No response
99%		

EXERCISE 120



(9: 8-11)

When Block 1 swings down and hits Block 2, which of the following will most likely happen?

Age 9		
3 %	O	Block 2 will not move at all.
18	O	Block 2 will swing off to the left.
70	●	Block 2 will swing off to the right.
4	O	The string holding Block 2 will break.
4	O	I don't know.
0		No response
99%		

EXERCISE 121

(9: 1-10)

You can see the Sun only in the daytime because

Age 9		
70 %	●	the Earth is turning.
3	O	people sleep at night.
3	O	there are more clouds at night.
22	O	the Sun shines only part of the time.
2	O	I don't know.
0		No response
100 %		

EXERCISE 122

(9: 1-8)

Which of the following insects are most helpful to man?

[illegible]	●	Honeybees
[illegible]	O	Lice
[illegible]	O	Locusts
[illegible]	O	Termites
[illegible]	O	I don't know.
[illegible]		No response
100 %		

EXERCISE 123

(9: 3-15)

What can scientists learn by studying some fossils?

Age 9		
9%	O	Why earthquakes took place
62	●	What animals lived long ago
14	O	How far the Moon is from Earth
8	O	What the weather will be tomorrow
7	O	I don't know.
0		No response
100 %		

EXERCISE 124

(9: 6-15)

Jane wrapped the end of a piece of wire around the base of a flashlight bulb. When she touched the bottom of the bulb to the center of the top of a new battery, the bulb did not light. What should Jane do next to light the bulb?

Age 9		
13%	o	Touch the end of the wire to the bulb.
4	o	Put the end of the wire in a drop of water.
11	o	Touch the bulb to the bottom of the battery.
61	●	Touch the end of the wire to the bottom of the battery.
10	o	I don't know.
1		No response
100 %		

EXERCISE 125

(9: 6-14)

Most land plants get most of their water directly from which of the following?

Age 9		
2%	o	Animals
3	o	Other plants
33	o	Rivers
59	●	The soil
2	o	I don't know.
1		No response
100 %		

EXERCISE 126

(9: 2-12)

Most scientists think that the center of the Earth is very

Age 9		
23 %	o	cold.
9	o	dusty.
58	●	hot.
6	o	muddy.
5	o	I don't know.
0		No response
101%		

EXERCISE 127

(9: 2-11)

The Sun and a penny are alike in which of the following ways?

Age 9		
5%	o	Both weigh the same.
57	●	Both are made of atoms.
14	o	Both are made of metals.
9	o	Both are at the same temperature.
14	o	I don't know.
0		No response
99 %		

EXERCISE 128

(9: 6-4)

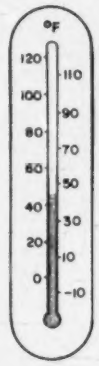
Our Sun is a

Age 9		
15%	O	planet.
12	O	satellite.
16	O	solar system.
52	●	star.
5	O	I don't know.
1		No response
101%		

EXERCISE 129

(9: 7-14)

It is sunny, there is little wind, and a thermometer outdoors in the shade looks like the picture below.



How should you dress to be comfortable outdoors?

Age 9		
6%	O	Wear a swim suit.
13	O	Just wear your indoor clothes.
52	●	Put on a sweater or light coat over your indoor clothes.
25	O	Put on a heavy coat, muffler, wool cap, and boots over your indoor clothes.
3	O	I don't know.
0		No response
99%		

EXERCISE 130

(9: 5-4) (similar to Exercise 205)

The temperature that is thought most comfortable for a schoolroom is about

Age 9		
15%	O	40° Fahrenheit.
18	O	50° Fahrenheit.
52	●	70° Fahrenheit.
5	O	90° Fahrenheit.
3	O	100° Fahrenheit.
8	O	I don't know.
0		No response
101%		

EXERCISE 131

(9: 1-4)

Cactus plants can live in the desert because

Age 9		
12%	O	they are all very large.
4	O	they have large flowers.
49	●	they lose little water through leaves.
24	O	there are no animals in the desert to eat them.
11	O	I don't know.
1		No response
101%		

EXERCISE 132

(9: 1-9)

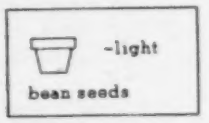
A different substance is formed when

Age 9		
12%	o	cloth is cut.
12	o	a cup breaks.
46	•	a candle burns.
13	o	a piece of chalk falls apart.
16	o	I don't know.
0		No response
99%		

EXERCISE 133

(9: 2-15)

Tom wanted to find out whether plants can grow better in the dark or in the light. He put a pot with 6 radish seeds in a dark room and a pot with 6 bean seeds on the window sill.



He added the same amount of water to both pots. The bean seeds grew better than the radish seeds, so Tom said his plants grow best in the light.

To be able to say this, he should have

Age 9		
14%	o	watered both pots more.
15	o	watered the radish seeds more.
44	•	put the same kind of seeds in both pots.
12	o	grown the seeds in water instead of soil.
15	o	I don't know.
0		No response
100 %		

EXERCISE 134

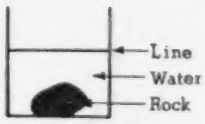
(9: 2-4)

Which of the following insects spread serious human diseases?

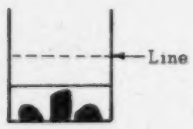
Age 9		
6%	o	Ants
19	o	Honeybees
44	•	Houseflies
22	o	Moths
9	o	I don't know.
0		No response
100 %		

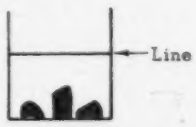
EXERCISE 135

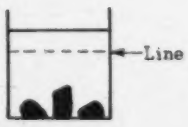
(9: 2-9)

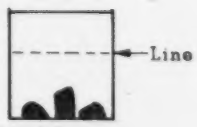


When a rock is put into a pail of water, the water comes up to the line as the picture above shows. If the rock is broken into three pieces, which of the following pictures shows how high the water is?









Age 9		
12 %	o	A
10	o	B
36	•	C
17	o	D
14	o	E
9	o	I don't know.
1		No response
99 %		

EXERCISE 136

(9: 2-18)

Which of the following is true of all matter?

Age 9		
12%	O	It has a shine.
19	O	It has no taste.
36	●	It takes up space.
10	O	It has a square shape.
23	O	I don't know.
0		No response
100%		

EXERCISE 137

(9: 3-14)

A quart of which of the following would weigh the most?

Age 9		
7%	O	Air
35	●	Mercury
5	O	Sawdust
48	O	Water
5	O	I don't know.
0		No response
100%		

EXERCISE 138

(9: 1-17)

Soon after a cold front has passed over St. Louis, one expects to find in St. Louis

Age 9		
34%	●	Clearing skies.
9	O	100 - mile - an - hour winds.
16	O	low atmospheric pressure.
22	O	the start of a 3 - day snow.
18	O	I don't know.
0		No response
99%		

EXERCISE 139

(9: 4-11)

Could a rock be broken into smaller and smaller pieces forever and still be rock?

Age 9		
25%	O	Yes, because most rocks are made up of several things.
15	O	Yes, because there is no smallest piece of rock.
27	●	No, because you would finally get to atoms.
27	O	No, because rocks are very hard.
6	O	I don't know.
0		No response
100%		

EXERCISE 140

(9: 5-5)

Coal is formed from

Age 9		
15%	●	dead plants.
14	O	sand and mud.
5	O	tiny sea animals.
56	O	lava from volcanoes.
10	O	I don't know.
0		No response
100%		

EXERCISE 141

(9: 7-5)

A pint of water at a temperature of 50° Fahrenheit is mixed with a pint of water at 70° Fahrenheit. The temperature of the water just after mixing will be about

Age 9		
4%	O	20° F.
2	O	50° F.
7	●	60° F.
5	O	70° F.
69	O	120° F.
12	O	I don't know.
0		No response
99%		

Age 9

Objective II. Possess the Abilities and Skills Needed to Engage in the Processes of Science

General Summary

In extending scientific laws and principles to occurrences in familiar and novel situations (recognizing the freezing point of water under several circumstances), errors were frequently made on an exercise requiring knowledge of the relatively abstract notion of validating mechanisms in scientific inquiry. Relatively concrete exercises were easier.

Most 9-year-olds could:

142. Balance one weight by hanging a second weight on a beam balance (96%).

143. Balance two weights by hanging a third weight on a beam balance (94%).

144. Select the leaf that gives off most water, knowing that big leaves give off most water (89%).

145. Given a table listing the weights of several elements in the human body, choose the most common element (oxygen) (80%). (See Exercise 150 for a question similar to this one.)

146. Analyze what needs to be investigated to cope with a slowly flattening bicycle tire (72%).

When presented with the following, a good many 9-year-olds could:

147. Choose the best way of verifying someone's recipe for making salt-water taffy (66%).

148. Conclude from a table of data the fact that young people generally breath faster than older people (66%).

149. Read a table of data showing temperatures at different times (63%).

150. Given a table listing the weights of several elements in the human body, choose the least common element (54%).

151. Given information showing the height of a plant at successive weeks, select the graph which accurately displays the growth of the plant (51%).

152. Recognize vaccination as the reason that so few people get smallpox (50%).

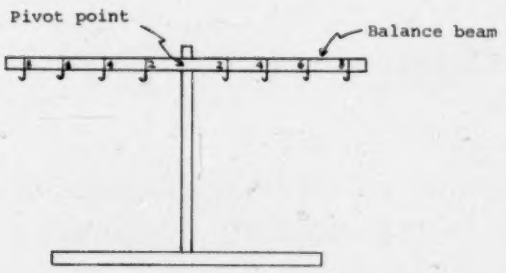
153. Identify a reasonable explanation as to why water does not come out of a faucet (35%).

Rather few 9-year-olds:

154. Were able to infer that water would freeze at 32 degrees F when given the fact that ice melts at 32 degrees F (17%).

EXERCISE 142

(9: 11-23A)



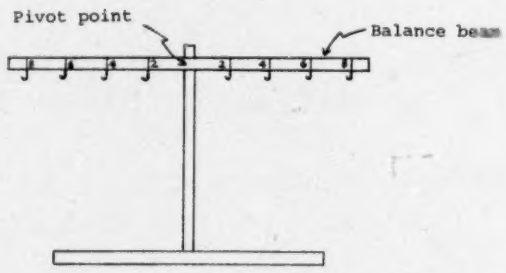
We want you to use this balance. The pivot point is the nail. The balance beam is the piece of metal which can turn on the pivot point. The balance beam is level when nothing is hanging from its hooks. The number by each hook on the beam tells the number of inches that hook is from the pivot point.

A. Hang one weight 4 inches left of the pivot point. The beam is not level now. Hang a second weight so that the beam is level again. Try to balance the beam on your first try, but keep trying until the beam is level. Where did you hang the second weight? (4)

Age 9		
96 %		Acceptable
2		Unacceptable
2		No response
100 %		

EXERCISE 143

(9: 11-23B)



We want you to use this balance. The pivot point is the nail. The balance beam is the piece of metal which can turn on the pivot point. The balance beam is level when nothing is hanging from its hooks. The number by each hook on the beam tells the number of inches that hook is from the pivot point.

B. Hang two weights 4 inches left of the pivot point. The beam is not level now. Hang a third weight so that the beam is level again. Try to balance the beam on your first try, but keep trying until the beam is level. Where did you hang the third weight? (8)

Age 9		
94 %		Acceptable
3		Unacceptable
3		No response
100 %		

EXERCISE 144

(9: 3-2)

Big leaves usually give off more water than little leaves. Which of the following leaves gives off the most water?

Age 9		
89 %	●	
2	○	
4	○	
3	○	
3	○	I don't know.
0		No response
101 %		

EXERCISE 145

(9: 7-17B) (similar to Exercise 229)

Weights of some Chemical Elements Found in a 100 pound Human	
Calcium	2 pounds
Carbon	18 pounds
Hydrogen	10 pounds
Oxygen	64 pounds
Phosphorus	14 ounces
Sodium	2 ounces
Sulfur	4 ounces

B. From the chart above, which chemical element is found in the GREATEST amount in the body?

Age 9		
2 %	○	Calcium
2	○	Carbon
4	○	Hydrogen
80	●	Oxygen
4	○	Phosphorus
7	○	I don't know.
2		No response
101 %		

EXERCISE 146

(9: 2-1)

John has a flat tire on his bicycle. He pumps the tire up with an air pump and begins to ride. In a few minutes the tire is flat again. To fix his tire, John must find

Age 9		
16%	○	a better air pump.
3	○	whether the tire is made of rubber.
72	●	where the air leaks out of the tire.
3	○	how many minutes it takes the tire to go flat.
4	○	I don't know.
1		No response
99%		

EXERCISE 147

(9: 8-9)

Someone said that if you mix salt and sugar with water and let the mixture stand you get salt-water taffy--a kind of candy. Which of the following would be the best way for you to test this idea?

Age 9		
3%	○	Take a vote among your friends.
13	○	Buy some salt-water taffy and see if it has salt in it.
7	○	Find out if salt and sugar have the same chemicals in them.
6	○	Grind up some salt-water taffy to see if you get salt, sugar, and water.
66	●	Try to mix salt, sugar, and water, let them stand, and see what happens.
5	○	I don't know.
0		No response
100%		

EXERCISE 148

(9: 7-13)

A doctor kept records of breathing rates of people when they were resting. He made the chart below.

BREATHING RATES

Person	Breaths in a minute
Baby boys	38
7 -yr. -old girls	25
7 -yr. -old boys	25
10 -yr. -old boys	20
Mothers	16

The chart suggests that

Age 9		
12%	○	boys breathe faster than girls.
2	○	girls breathe faster than boys.
14	○	older people breathe faster than younger people.
66	●	younger people breathe faster than older people.
6	○	I don't know.
0		No response
100%		

EXERCISE 149

(9: 6-6)

John took the outside temperature in the morning, at noon, and at night for two days. His record is shown below.

Day	Morning	Noon	Night
Tuesday	19°F	16°F	14°F
Wednesday	20°F	16°F	13°F

When was the temperature highest?

Age 9		
13%	○	Tuesday morning
7	○	Tuesday noon
63	●	Wednesday morning
10	○	Wednesday noon
5	○	I don't know.
2		No response
100%		

EXERCISE 150

(9: 7-17A) (similar to Exercise 231)

Weights of some Chemical Elements Found in a 100 pound Human	
Calcium	2 pounds
Carbon	18 pounds
Hydrogen	10 pounds
Oxygen	64 pounds
Phosphorus	14 ounces
Sodium	.2 ounces
Sulfur	4 ounces

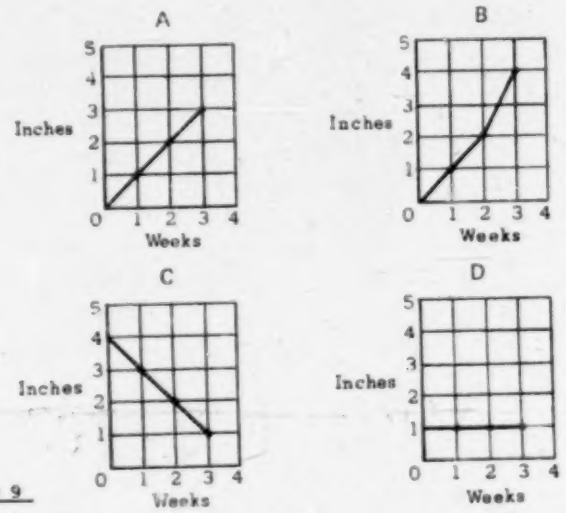
A. From the chart above, which of the following chemical elements is found in the SMALLEST amount in the body?

Age 9		
14 %	o	Calcium
5	o	Carbon
8	o	Hydrogen
54	●	Sodium
7	o	Sulfur
11	o	I don't know.
1		No response
100 %		

EXERCISE 151

(9: 8-4)

A plant grows this way: The first week it is 1 inch high. The second week it is 2 inches high. The third week it is 4 inches high. Which of the following graphs shows this growth?



Age 9		
11 %	o	A
51	●	B
13	o	C
9	o	D
15	o	I don't know.
0		No response
99 %		

EXERCISE 152

(9: 2-10) (overlaps Exercise 435)

Why do very few people get smallpox in the United States today?

Age 9		
12 %	o	The weather conditions have changed.
50	●	Most people get smallpox vaccinations.
6	o	People move more often than they used to.
4	o	People drink more milk today than ever before.
17	o	All the germs that cause smallpox have been killed.
11	o	I don't know.
0		No response
100 %		

EXERCISE 153

(9: 4-15)

You turn on a water faucet in your home and find that no water comes out. Which of the following could NOT have caused this to happen?

Age 9		
35%	●	The sink is full of water.
9	o	The water pipe if full of rust.
26	o	A water pipe is broken somewhere.
26	o	Your home has been cut off from the water supply.
3	o	I don't know.
0		No response
99%		

EXERCISE 154

(9: 3-5)

Ice melts to water at 32°F. If water is cooled from 40°F, one should expect the freezing to take place at

Age 9		
31 %	o	30°F or lower.
17	•	32°F.
7	o	33°F.
30	o	34°F or higher.
14	o	I don't know.
0		No response
99 %		

Objective III. Understand the Investigative Nature of Science

General Summary

Nine-year-olds seemed to do fairly well in identifying characteristics of scientific experiments and phenomena amenable to investigation. Rather few 9s, however, were able to deal with definitions of scientific theory or to decide which activity has little relevance to science.

Most 9-year-olds:

155. Recognized that observation is a basic characteristic of scientific experiment (91%).

156. Recognized that phenomena are amenable to scientific inquiry even where a rational explanation is not immediately available (78%).

A good many recognized correctly that:

157. A value judgment is a question unsuitable for scientific inquiry (38% selected "My dog is better than your dog" as such a judgment).

Rather few:

158. Recognized a simple definition of a scientific theory (22%). About a fourth (27%) identified a scientific theory as a description of an experiment.

159. Selected from among five alternatives the one--"write a poem"--which had least to do with scientific description (22%). Nearly a third (31%) selected finding out the number of seeds in an apple as least pertinent to scientific description.

EXERCISE 155

(9: 1-19)

A man has been planting seeds and keeping records of how fast they grow. Could he be doing a science experiment?

Age 9		
91%	●	Yes
7	O	No
2	O	I don't know.
0		No response
100%		

EXERCISE 156

(9: 3-8)

Mary blew up a balloon and rubbed it against the wall of her room. When she took her hand away, the balloon stayed on the wall without falling. Mary's friends who saw this said the following things about the balloon. Which is the most scientific?

Age 9		
7%	O	I do not believe that the balloon stayed up.
9	O	It is a magic trick and cannot be explained.
3	O	The balloon wanted to stay on the wall and not fall down.
78	●	I cannot explain it, but there must be a reason why it stays up.
3	O	I don't know.
0		No response
100%		

EXERCISE 157

(9: 6-3) (similar to Exercise 242)

Scientists would have most trouble testing which of the following?

Age 9		
12%	O	I have a fever.
6	O	I weigh 101 pounds.
14	O	I am 62 inches tall.
13	O	I can lift a 20-pound box.
38	●	My dog is better than your dog.
16	O	I don't know.
1		No response
100%		

EXERCISE 158

(9: 8-14) (overlaps Exercise 244)

What is a scientific theory?

Age 9		
4%	O	It uses arithmetic.
12	O	It describes a scientist.
27	O	It describes an experiment.
18	O	It tells all there is to know about something.
22	●	It explains why some things act the way they do.
18	O	I don't know.
0		No response
101%		

EXERCISE 159

(9: 5-12)

In science one is LEAST likely to do which of the following things with an apple?

Age 9		
17%	O	Weigh it.
11	O	Measure its size.
11	O	Describe its color.
22	●	Write a poem about it.
31	O	Find how many seeds it has.
9	O	I don't know.
0		No response
101%		

Objective IV. Have Attitudes about and Appreciation of Scientists, Science, and the Consequences of Science that Stem from Adequate Understandings

General Summary

The two released exercises both deal with superstition.

160. About three-fourths of the children did not endorse the statement that number 13 brings bad luck (74%). A fifth of them (20%) did indicate they believed the number 13 brings bad luck.

161. About half denied that walking under a ladder, breaking a mirror, or having a black cat cross one's path has bad consequences (45%). A quarter (28%) thought breaking a mirror meant bad luck.

EXERCISE 160

(9: 8-17)

Do you think that the number thirteen (13) brings you bad luck?

Age 9		
20 %	o	Yes
74	•	No
6	o	I don't know.
0		No response
100 %		

EXERCISE 161

(9: 5-8)

Which of the following will cause you to have bad luck for several years?

Age 9		
28 %	o	Breaking a mirror
10	o	Walking under a ladder
12	o	Letting a black cat cross your path
45	•	None of these
4	o	I don't know.
1		No response
100 %		

Age 13

Objective I. Know the Fundamental Facts and Principles of Science

General Summary

All of the exercises for this objective were multiple-choice. Difficulty is influenced not only by the concept being assessed, but also by the difficulty and the potential for confusion induced by the alternatives offered. Most 13-year-olds answered correctly when asked about simple scientific facts, many which are close to everyday experience (baby comes from its mother, brushing teeth prevents tooth decay, dark clouds bring rain, fanning a fire makes it burn faster, etc.).

Exercises answered correctly by a good many 13-year-olds tended to be farther removed from everyday experience. Some required knowledge of prehistoric man, the formation of fossils, or the movement of air masses--all actions or things inaccessible to direct observation. Others required awareness of scientific principles of molecular movement, pasteurization, and the like. Other exercises of this difficulty, while drawing on observation, also called for application of theoretical ideas (e.g. refraction of light by water).

The most difficult exercises did not deal with any single type of content. Often the chosen single alternative required a precise discrimination. For example, one exercise asked the students to choose which of five parts of the central nervous system is the center of memory and intelligence. Exercises on molecular theory and chemical reactions were generally difficult.

Most 13-year-olds responded correctly that:

201. The human baby comes from its mother's body (98%).

202. You brush your teeth to keep them from decaying (98%).

203. Thick dark-gray clouds are more likely than others to bring rain on a summer day (93%).

204. The best balanced meal (from among five alternatives given) includes steak, bread, carrots, and milk (89%).

205. The comfortable temperature for a schoolroom is 70 degrees F (86%).

206. Fanning a fire makes it burn better because fanning increases the supply of oxygen to the fire (79%).

207. Cancer is a disease that cannot, at present, be controlled by a vaccine (78%).

208. Even without atmosphere the launching of a rocket from the moon is possible (74%). (This result was obtained in the fall of 1969, after the lunar landing.)

A good many 13-year-olds responded correctly that:

209. Sedimentary rock usually forms in layers (65%).

210. The earliest men on earth were probably small, hairy, and stooped (63%).

211. In hot water the molecules are moving faster than in cold water (61%).

212. Predicting the movement of air masses is an important factor in predicting weather. (59%).

213. A human action such as draining a swamp can upset the ecology of a small area (57%).

214. A second weight can be hung at an appropriate position to balance another weight (55%).

215. Flower seeds develop from the ovules rather than leaves, petals, roots, or stems (54%).

216. The apparent bending of a spoon in a glass of water is explained by refraction of light (51%).

217. Most of the chemical energy expended in the automobile engine is not used to move the car but is changed into heat (48%).

218. Mercury can be used in a glass thermometer because when heated it expands more than the glass (45%).

219. Pasteurization of milk kills bacteria harmful to man (40%).

220. A block of wood is more buoyant in salt water than in fresh water (39%).

221. Most caves are formed by the action of underground water on limestone (38%).

222. Natural selection offers an explanation for why giraffes have long necks (38%).

223. A body covering of feathers is what distinguishes birds from all other animals (36%).

224. Our knowledge of atoms is based on observation of how matter behaves (34%).

Rather few children of this age level correctly responded to exercises on the following:

225. A good thing to do when someone faints is to lay him down and keep him warm (32%).

226. As a candle burns, molecules of a different kind are formed (27%).

227. The cerebrum is the brain's center for memory and intelligence (26%).

228. The presence of an ocean fish fossil on a mountain outcrop is best explained by the hypothesis that the mountain was raised up after the fish had died (26%). About half (53%) thought the best explanation was that the fossil fish was carried to the mountain by a great flood.

EXERCISE 201

(13: 7-15) (overlaps Exercise 101)

Where does a human baby come from?

Age 13		
0%	O	The stork brings the baby.
98	●	The baby comes from its mother's body.
0	O	The doctor gives the baby to the mother.
0	O	The father buys the baby for the mother.
0	O	The hospital keeps many babies and the mother picks one out.
0	O	I don't know.
1		No response
99%		

Not administered to the in-school sample in one Southeastern county and one Southeastern city at the request of state or local authorities.

EXERCISE 202

(13: 1-1) (overlaps Exercise 103)

For which of the following reasons should you brush your teeth?

Age 13		
0%	O	To straighten your teeth
1	O	To make your teeth harder
0	O	To make your teeth sharper
0	O	To help your teeth grow larger
98	●	To help keep your teeth from decaying
0	O	I don't know.
0		No response
99%		

EXERCISE 203

(13: 4-10) (similar to Exercise 106)

On a summer day, which of the following clouds is most likely to bring rain?

Age 13		
1%	O	Thin fluffy clouds
1	O	Red clouds at sunset
93	●	Thick dark-gray clouds
3	O	Clouds that look like white sheep
1	O	A few lines of clouds high in the sky
1	O	I don't know.
0		No response
100%		

EXERCISE 204

(13: 7-11) (overlaps Exercise 302)

Which of the following would most closely represent a balanced meal?

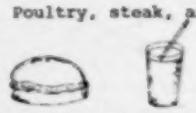
Age 13

89% ● Steak, bread, carrots, and milk

1 O Ice - cream soda and cake

5 O Potatoes, oatmeal, bread, and bananas

3 O Poultry, steak, and fish



1 O Hamburger and coke

0 O I don't know.

0 No response

99%

EXERCISE 205

(13: 6-2) (similar to Exercise 130)

The temperature that is considered most comfortable for a schoolroom is about

Age 13		
1%	O	40° Fahrenheit.
7	O	50° Fahrenheit.
86	●	70° Fahrenheit.
2	O	90° Fahrenheit.
0	O	100° Fahrenheit.
3	O	I don't know.
0		No response
99%		

Exercise 206

(13: 6-11)

Fanning can make a campfire burn better because the fanning

Age 13		
3%	O	raises the atmospheric pressure.
2	O	warms materials to their kindling points.
3	O	increases the supply of material that can burn.
79	●	increases the supply of oxygen for the burning.
10	O	provides the energy needed to keep the fire going.
2	O	I don't know.
0		No response
99%		

EXERCISE 207

(13: 4-1)

Which of the following diseases presently CANNOT be controlled by a vaccine that one receives by inoculation (shot) or swallowing?

Age 13		
78%	●	Cancer
7	O	Polio
2	O	Smallpox
3	O	Tetanus
4	O	Typhoid fever
5	O	I don't know.
1		No response
100%		

EXERCISE 208

(13: 5-8)

Which of the following could be done on the Moon, where there is no air?

Age 13		
1%	O	Flying a kite
3	O	Building a bonfire
2	O	Flying an airplane
17	O	Floating a balloon
74	●	Launching a rocket
3	O	I don't know.
0		No response
100%		

EXERCISE 209

(13: 4-6)

Which of the following is usually true of sedimentary rock?

Age 13		
65 %	●	It is formed in layers.
5	o	It has large shiny crystals.
5	o	It will dissolve easily in water.
4	o	It is formed on mountain tops.
3	o	It can be melted over a burner flame.
18	o	I don't know.
0		No response
100 %		

EXERCISE 210

(13: 5-4)

Recent scientific observations indicate that the earliest men on Earth

Age 13		
3 %	o	lived in cities.
4	o	lived on ocean beaches.
63	●	were small, hairy, and stooped.
6	o	had brains the size of a walnut.
12	o	lived near the north and south poles.
12	o	I don't know.
0		No response
100 %		

EXERCISE 211

(13: 3-13) (overlaps Exercise 419)

Which of the following is true of hot water as compared with cold water?

Age 13		
9 %	o	It is denser.
3	o	It is easier to see through.
61	●	Its molecules are moving faster.
9	o	It has more free oxygen dissolved in it.
6	o	It has more free hydrogen dissolved in it.
12	o	I don't know.
0		No response
100 %		

EXERCISE 212

(13: 5-12) (overlaps Exercise 305) (similar to Exercise 403)

Information about which one of the following is most important in predicting weather?

Age 13		
1 %	o	The available supplies of water
12	o	The daily extremes of humidity
4	o	The daily extremes of wind speed
17	o	The daily extremes of temperature
59	●	The movement and characteristics of air masses
6	o	I don't know.
0		No response
99 %		

EXERCISE 213

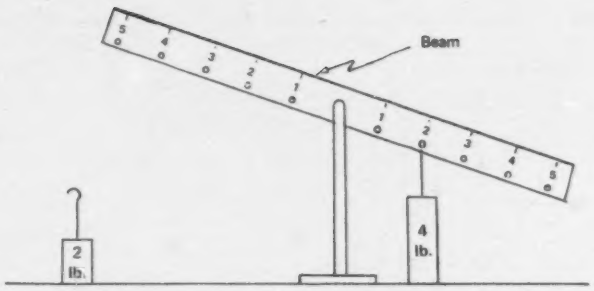
(13: 8-7)

Which of the following would LEAST upset the balance of animal and plant life in a small area?

Age 13		
24 %	O	Burning a forest
5	O	Draining a swamp
6	O	Constructing a dam
57	●	Broadcasting radio waves
5	O	Killing all hawks, owls, and vultures in the area
3	O	I don't know.
0		No response
100 %		

EXERCISE 214

(13: 7-4)



In order to make the beam balance, you should hang a 2-pound weight on the left-hand side at position

Age 13		
6 %	O	1.
14	O	2.
6	O	3.
55	●	4.
14	O	5.
4	O	I don't know.
0		No response
99 %		

EXERCISE 215

(13: 5-2) (overlaps Exercise 411)

Flower seeds develop from

Age 13		
2 %	O	leaves.
54	●	ovules.
15	O	petals.
15	O	roots.
6	O	stems.
9	O	I don't know.
0		No response
101 %		

EXERCISE 216

(13: 4-2)

A spoon in a glass of water appears to bend sharply at the water surface. This apparent bending is due to

Age 13		
7 %	O	absorption.
5	O	color bands.
7	O	interference.
51	●	refraction.
15	O	shadows.
15	O	I don't know.
0		No response
100 %		

EXERCISE 217

(13: 6-10) (similar to Exercise 413)

Most of the chemical energy of the gasoline burned in a car is not used to move the car but is changed into

Age 13		
24 %	o	electricity.
48	●	heat.
1	o	light.
8	o	magnetism.
3	o	sound.
16	o	I don't know.
0		No response
100 %		

EXERCISE 218

(13: 7-2) (similar to Exercise 317)

Mercury can be enclosed in glass to make a thermometer because mercury

Age 13		
11 %	o	is a metal
8	o	is more dense than glass.
19	o	conducts heat better than glass.
2	o	conducts electricity better than glass.
45	●	expands more than glass when both are heated together.
14	o	I don't know.
0		No response
99 %		

EXERCISE 219

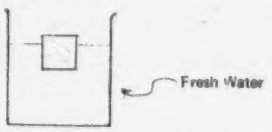
(13: 3-5)

Which of the following best describes the results of pasteurization of milk?

Age 13		
25 %	o	All bacteria are killed.
23	o	The milk is homogenized.
4	o	The taste of milk is improved.
40	●	Bacteria harmful to man are killed.
5	o	The milk is permanently kept from spoiling.
3	o	I don't know.
0		No response
100 %		

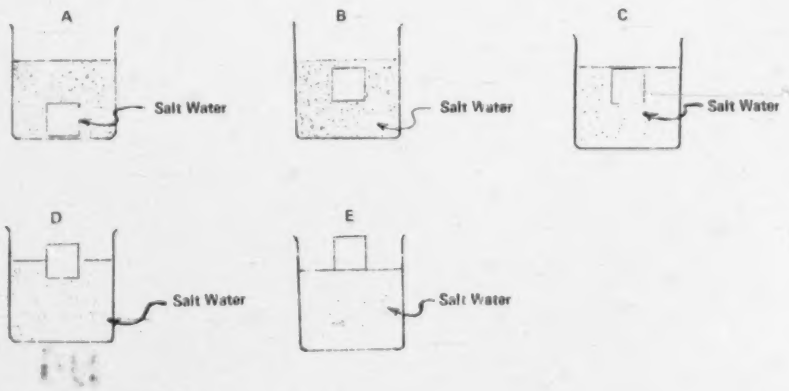
EXERCISE 220

(13: 4-9)



A block of wood floats in fresh water as shown above. If this block were placed in salt water from the ocean, which of the following diagrams shows what would happen?

Age 13		
13 %	o	A
4	o	B
8	o	C
39	●	D
28	o	E
8	o	I don't know.
0		No response
100 %		



EXERCISE 221

(13: 7-14) (overlaps Exercise 422)

Most caves are formed by the action of underground water on

Age 13		
10 %	O	granite.
38	●	limestone.
4	O	pumice.
23	O	sandstone.
6	O	shale.
18	O	I don't know.
0		No response
99 %		

EXERCISE 222

(13: 8-8) (similar to Exercise 314)

In terms of the theory of natural selection, what is the explanation of why giraffes have come to have such long necks?

Age 13		
8 %	O	Stretching to get food in high trees has made their necks longer.
2	O	There is something inside of giraffes which keeps making longer necks.
12	O	Giraffe food contained vitamins which caused vertebrae to lengthen.
28	O	Giraffe necks have gotten longer and longer as time has gone on, but nobody has any idea why this is.
38	●	Giraffes born with the longest necks have been able to stay alive when food was scarce and have passed this trait on to their offspring.
12	O	I don't know.
0		No response
100 %		

EXERCISE 223

(13: 7-13) (overlaps Exercise 321)

Which of these is characteristic of birds but of no other animals?

Age 13		
37 %	O	Ability to fly
2	O	Ability to lay eggs
10	O	Tendency to migrate
36	●	Body covering of feathers
10	O	Regulated body temperature
4	O	I don't know.
1		No response
100 %		

EXERCISE 224

(13: 3-12)

Why do we think that matter is made up of atoms?

Age 13		
41 %	O	We can see atoms with a microscope.
1	O	We can see atoms with our unaided eyes.
2	O	We can see atoms with a magnifying glass.
34	●	Matter behaves as if it were made up of atoms.
10	O	A famous wise man said many hundreds of years ago that matter is made of atoms.
11	O	I don't know.
0		No response
99 %		

EXERCISE 225

(13: 9-6)

Which of the following should you do when a person faints?

Age 13		
0 %	O	Tightly bandage him.
32	●	Lay him down and keep him warm.
1	O	Hold him up and apply hot packs.
12	O	Hold him up and apply cold packs.
48	O	Lay him down and apply cold packs.
7	O	I don't know.
0		No response
100 %		

EXERCISE 226

(13: 9-10)

Which of the following most clearly forms molecules different from those present at the start?

Age 13		
41 %	O	Ice melting
4	O	A cup breaking
4	O	Cloth being torn
27	●	A candle burning
11	O	A piece of chalk falling apart
13	O	I don't know.
0		No response
100 %		

EXERCISE 227

(13: 7-6) (overlaps Exercise 427)

In mammals, which of the following is the center of memory and intelligence?

Age 13		
21 %	O	Cerebellum
26	●	Cerebrum
11	O	Medulla
10	O	Optic nerve
7	O	Spinal cord
25	O	I don't know.
0		No response
100 %		

EXERCISE 228

(13: 9-7) (overlaps Exercise 425)

A fossil of an ocean fish was found in a rock outcrop on a mountain. This probably means that

Age 13		
3 %	O	fish once lived on the mountain.
3	O	the relative humidity was once very high.
26	●	the mountain was raised up after the fish died.
10	O	fish used to be amphibians like toads and frogs.
53	O	the fossil fish was probably carried to the mountain by a great flood.
5	O	I don't know.
0		No response
100 %		

Objective II. Possess the Abilities and Skills Needed to Engage in the Processes of Science

General Summary

Exercises causing students least difficulty were those requiring them to form a simple hypothesis employing elementary scientific knowledge (e.g. to suggest why paint on one side of a house had deteriorated more than paint on the remaining sides). Interpretation of tabular data was more complex. Most children of this age level were able to :

229. Select from a chart listing weights of various common elements found in the human body, the element that is most abundant (oxygen) (92%).

230. Choose from among several possibilities the best hypothesis for why paint on one side of a house doesn't last as well as the paint on the remaining sides (83%).

231. Select from a chart listing weights of various common elements found in the human body, the scarcest element (sodium) (81%).

232. From pictures showing how high three solids of the same size float, determine which is heaviest (75%).

233. Interpret a graph showing the effect of different diets on the weight of guinea pigs (71%).

Given the following exercises, a good many 13-year-olds could:

234. Balance a beam balance with a weight (64%).

235. Interpret tabular data to correctly determine which series of four weights best establishes that one object is heavier than another (62%).

236. Correctly use a graph and tabular data to determine the food needs of a dog (61%).

237. Perform a simple experiment by measuring the time takes a pendulum to swing back and forth 10 times (38%).

238. Select from a variety of laboratory apparatus the equipment necessary to determine the boiling point of water (36%).

Rather few 13-year-olds:

239. Chose from a variety of line graphs the one best showing average, normal height increases in children as a function of their age (27%).

240. Found out the density of a wood block using the beam balance and a weight of a known mass (4%).

EXERCISE 229

(13: 9-13B) (similar to Exercise 145)

Weights of some Chemical Elements Found in a 100 pound Human	
Calcium	2 lb.
Carbon	18 lb.
Hydrogen	10 lb.
Oxygen	64 lb.
Phosphorus	14 oz.
Sodium	2 oz.
Sulfur	4 oz.

B. From the chart above, which chemical element is found in the GREATEST amount in the body?

Age 13		
2%	o	Calcium
1	o	Carbon
1	o	Hydrogen
92	●	Oxygen
1	o	Phosphorus
1	o	I don't know.
0		No response
98%		

EXERCISE 230

(13: 4-15) (overlaps Exercise 436)

A man notices that the paint on one side of his house is not lasting as well as the paint on the other sides. Which of the following is the most likely cause?

Age 13		
5%	o	Termites
8	o	Cosmic rays
83	●	Wind or sun
0	o	Fallout from atom bombs
1	o	Sonic booms from low-flying jets
3	o	I don't know.
0		No response
100%		

EXERCISE 231

(13: 9-13A) (similar to Exercise 150)

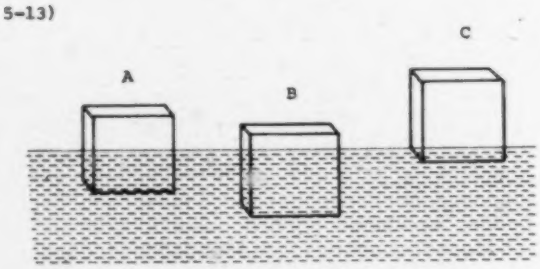
Weights of some Chemical Elements Found in a 100 pound Human	
Calcium	2 lb.
Carbon	18 lb.
Hydrogen	10 lb.
Oxygen	64 lb.
Phosphorus	14 oz.
Sodium	2 oz.
Sulfur	4 oz.

A. From the chart above, which of the following chemical elements is found in the least amount in the body?

Age 13		
3%	o	Calcium
3	o	Carbon
4	o	Hydrogen
81	●	Sodium
6	o	Sulfur
2	o	I don't know.
1		No response
100%		

EXERCISE 232

(13: 5-13)

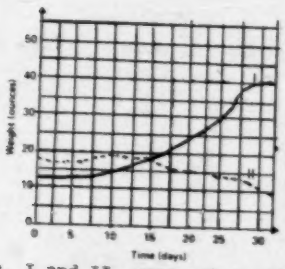


The three solid objects shown above have the same volume. If they float as shown in the diagram, which one weighs the most?

Age 13		
0%	o	Object A
75	●	Object B
4	o	Object C
6	o	They all weigh the same.
14	o	It is impossible to tell without additional information.
1	o	I don't know.
o		No response
100%		

EXERCISE 233

(13: 3-14)



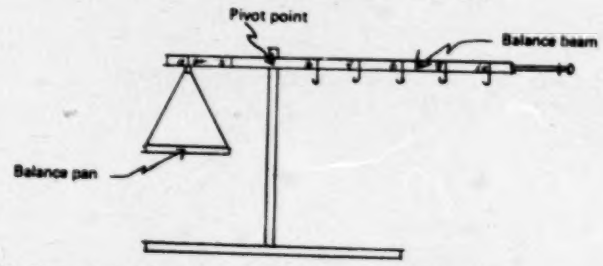
Two guinea pigs, I and II, were put on different diets for a month. The graph above shows what happened to their weights. Which of the following statements is correct according to the information in the graph?

Age 13

8 %	O	Guinea pig I lost weight while guinea pig II gained weight.
3	O	Guinea pig I and guinea pig II weighed the same at the beginning of the experiment.
71	●	Guinea pig I and guinea pig II weighed the same on the 15th day of the experiment.
4	O	Guinea pig I was given meat and corn whereas guinea pig II was given sugar and crackers.
9	O	Guinea pig II lost weight at first, but started to gain about halfway through the experiment.
4	O	I don't know.
2		No response
101 %		

EXERCISE 234

(13: 13-21a1) (overlaps exercises 341 and 438)



The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

1. Place one weight in the balance pan. How many inches from the pivot point is the hook on which you must hang one weight to get balance? (4)

Age 13

64 %	Correct
34	Incorrect
2	No response
100%	

The apparatus also included fishweights, one to place in the balance pan, and another to use to achieve balance. The respondent was given 20 minutes to find the answer to this and other questions involving the use of the apparatus (see Exercise 240).

EXERCISE 235

(13: 7-8) (overlaps exercises 340 and 439)

In each of five experiments, two objects were weighed four times each. Which experiment gives the strongest evidence that object I weighs more than object II?

1 Age 13

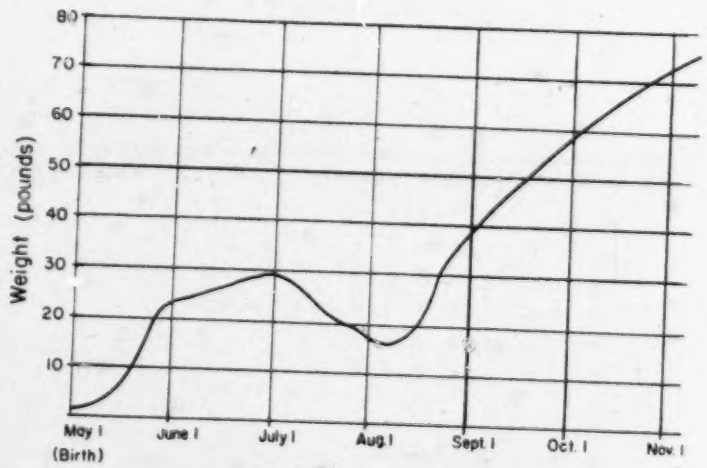
			Object I	Object II
62 %	●	Experiment A	80 lb.	70 lb.
			81 lb.	69 lb.
			80 lb.	71 lb.
			82 lb.	70 lb.
9	O	Experiment B	69 lb.	81 lb.
			71 lb.	82 lb.
			70 lb.	80 lb.
			70 lb.	80 lb.
3	O	Experiment C	70 lb.	80 lb.
			75 lb.	75 lb.
			77 lb.	73 lb.
			80 lb.	70 lb.
3	O	Experiment D	80 lb.	70 lb.
			75 lb.	75 lb.
			73 lb.	77 lb.
			70 lb.	80 lb.
9	O	Experiment E	80 lb.	77 lb.
			79 lb.	76 lb.
			78 lb.	75 lb.
			77 lb.	74 lb.
12	O	I don't know		
2		No response		
100 %				

EXERCISE 236

(13: 9-14c)

Michael kept a record of his dog's weight from birth on May 1 in order to find out how much dog food to give his dog. The directions on the bag of dog food for feeding a dog are as follows:

Weight of Dog	Number of Cups of Food Daily
Under 20 pounds	1
20 to 40 pounds	2
41 to 60 pounds	3
Over 60 pounds	4



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EXERCISE 236
(continued)

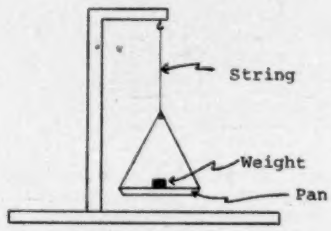
(13: 9-14c)

In what month should the dog's daily allowance have been increased to 4 cups?

Age 13		
4 %	O	July
9	O	August
8	O	September
61	●	October
15	O	November
3	O	I don't know.
0		No response
100 %		

EXERCISE 237

(13: 13-21c1) (overlaps exercises 344 and 441)



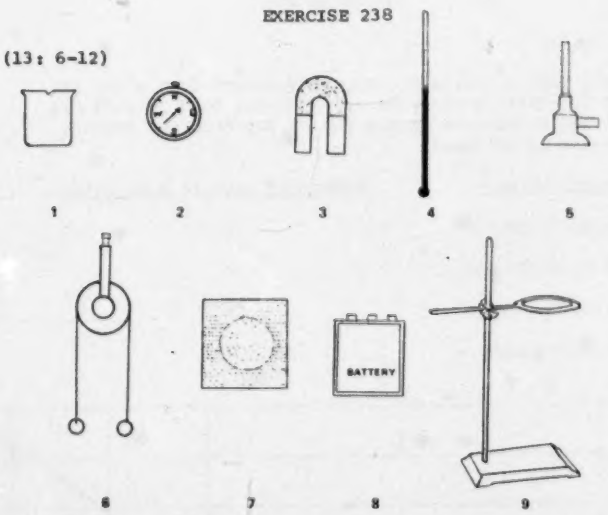
The apparatus before you is a pendulum. You have a watch or clock also.

1. How long does it take for the weight in the pan on the end of the string to swing back and forth ten times? _____ seconds (An answer between 11 and 15 seconds was scored correct.)

Age 13	
38 %	Correct
56	Incorrect
6	No response
100 %	

EXERCISE 238

(13: 6-12)



Select the pieces of apparatus shown above that one would use to find the boiling point of water.

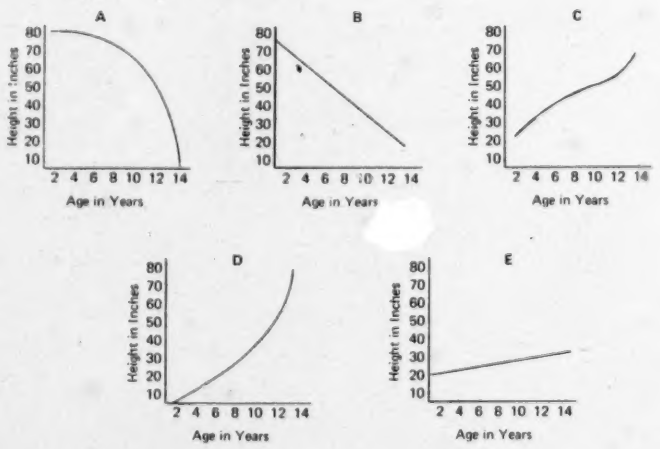
Age 13		
15 %	O	1, 4, 5, 6, 7
17	O	1, 4, 5, 6, 9
36	●	1, 4, 5, 7, 9
4	O	2, 3, 4, 6, 7
10	O	4, 5, 6, 8, 9
17	O	I don't know.
1		No response
100 %		

EXERCISE 239

(13: 2-9) (similar to Exercise 442)

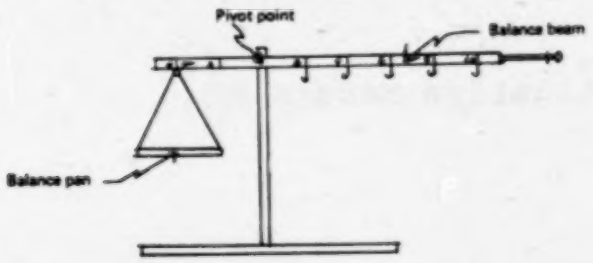
Which of the following graphs could show the average height in inches of a group of children growing at a normal rate plotted against their age in years?

Age 13		
16 %	O	A
14	O	B
27	●	C
16	O	D
10	O	E
16	O	I don't know.
0		No response
99 %		



EXERCISE 240

(13; 13-21a5) (overlaps exercises 348 and 445)



The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

(The apparatus also included 10-gram fishweights, a centimeter ruler, and a block of wood 10 x 3 x 2 centimeters. Respondents were given 20 minutes to answer several related questions (e.g., see Exercise 234). The following question was preceded by others which required them to make measurements which would assist them in answering it.)

5. What is the density of the wood block? It is _____ grams per cubic centimeter. (An answer between .38 and .64 was scored correct.)

Age 13	
4 %	Correct
70	Incorrect
27	No response
99 %	

Age 13

Objective III. Understand the Investigative Nature of Science

General Summary

Most 13s were able correctly to:

241. Select from a variety of skills (music, magic, marketing, mathematics, and manufacturing) the one (mathematics) which is most useful to scientific research (79%).

242. Recognize that the statement, "My dog is better than your dog," is not a question amenable to scientific inquiry (73%).

243. Recognize that repeated measures of the same thing will usually yield successive results which are close to each other but not all exactly the same (69%).

A good many 13-year-olds correctly responded on the following:

244. The basic purpose of a scientific theory is to explain why things act as they do (56%).

EXERCISE 241

(13: 7-7) (overlaps Exercise 349)

Skill in which of the following is most useful in scientific research?

Age 13		
1%	O	Music
4	O	Magic
1	O	Marketing
79	●	Mathematics
12	O	Manufacturing
3	O	I don't know.
0		No response
100%		

EXERCISE 242

(13: 2-1) (similar to Exercise 157)

Scientists would have most trouble testing which of the following?

Age 13		
6%	O	I have a fever.
4	O	I am 62 inches tall.
2	O	I weigh 101 pounds.
8	O	I can lift a 20-pound box.
73	●	My dog is better than your dog.
7	O	I don't know.
0		No response
100%		

EXERCISE 243

(13: 8-14) (overlaps exercises 350 and 446)

Whenever scientists carefully measure any quantity many times, they expect that

Age 13		
19%	O	all of the measurements will be exactly the same.
2	O	only two of the measurements will be exactly the same.
4	O	all but one of the measurements will be exactly the same.
69	●	most of the measurements will be close but not exactly the same.
6	O	I don't know.
0		No response
100%		

EXERCISE 244

(13: 9-5) (overlaps Exercise 158)

What is a scientific theory?

Age 13		
1%	O	It uses arithmetic.
4	O	It describes a scientist.
19	O	It describes an experiment.
14	O	It tells all there is to know about something.
56	●	It explains why some things act the way they do.
5	O	I don't know.
0		No response
99%		

Objective IV. Have Attitudes about and Appreciation of Scientists, Science, and the Consequences of Science that Stem from Adequate Understandings

General Summary

The following exercises deal with having accurate attitudes about scientists and having scientific curiosity about things in everyday life. Most 13-year-olds expressed attitudes consistent with the objective.

245. They indicated they believe that women can be successful scientists (94%).

246. Most indicated they did not believe that scientists always work in laboratories (91%).

247. Only a few indicated great curiosity about why things in nature are the way they are (8% said they had such curiosity "often," another 64% "sometimes").

EXERCISE 245

(13: 2-10)

Women can be successful scientists.

Age 13		
94 %	●	I believe this statement.
5	O	I don't believe this statement.
1	O	I don't know.
0		No response
100%		

EXERCISE 246

(13: 8-15)

Do you think that scientists always work in laboratories?

Age 13		
9 %	O	Yes
91	●	No
1	O	I don't know.
0		No response
101 %		

EXERCISE 247

(13: 7-16A)

A. Do you ask questions about why things in nature are the way they are?

Age 13		
8 %	●	Often
64	O	Sometimes
28	O	Never
1		No response
101 %		

Objective I. Know Fundamental Facts and Principles of Science

General Summary

There is a great range of difficulty among these exercises. In general, the harder exercises seem to call for text-bookish information.

The easiest exercises include a few which appear to be common knowledge--what foods make up a balanced meal; what group of animals and plants would be found in a desert community. However, others call for information one would be most likely to learn in school--the idea of natural selection is usually associated with Darwin's theory of evolution; an electric current in a copper wire involves mainly the movement of electrons.

Most 17-year-olds responded correctly to exercises on the following:

301. Snakes, road runners, cactus, and sagebrush belong to a group of animals and plants which would be found in a desert community (98%).

302. An example of a balanced meal is steak, bread, carrots, and milk (95%).

303. Nearly all gasoline at the present time comes from petroleum (93%).

304. Among five animals that have been found as fossils in rocks, only dinosaurs have never been seen alive by man (89%).

305. The movement and characteristics of air masses is the most important information (of five alternatives) for predicting weather (77%).

306. All of five alternatives help to increase the total amount of food available to the human race EXCEPT outlawing the use of insecticides (70%).

307. Any galaxy contains many stars (69%). More than a fifth of the 17s chose the response "planets" (22%).

308. An electric current in a copper wire involves mainly the movement of electrons (69%).

309. The idea of natural selection is usually associated with Darwin's theory of evolution (68%). Almost a fifth of the 17s said they didn't know who had proposed the theory (19%).

310. Changes such as the conversion of limestone to marble or of soft coal to hard coal are explained as having been brought about by heat and pressure below the Earth's surface (69%).

A good many 17s chose the correct response to exercises calling for the following information:

311. The solid, liquid, and gaseous states of water differ in the average speed with which the molecules are moving (65%).

312. Certain wavelengths of light can be detected with unaided human eyes (61%). The choice, "X-rays" was made by 17% of the 17s.

313. Research into the nature of matter shows that it is made up of individual moving particles (58%).

314. Giraffes have come to have such long necks because those born with the longest necks have been able to stay alive when food was scarce, and have passed this trait on to their offspring (58%).

315. The temperature of 2 pints of water at 40 degrees F mixed with one pint of water at 100 degrees F will be about 60 degrees F (57%).

316. Adrenaline acts as a stimulant to the heart (56%).

317. Mercury can be enclosed in glass to make a thermometer because mercury expands more than glass when both are heated together (56%).

318. "Atoms are rearranged into new molecules" most nearly describes what occurs for most chemical changes (54%).

319. The longer a rock falls, the greater is its speed (54%). Two other choices, acceleration (17%) and potential energy (18%) were popular incorrect responses.

320. A boat travelling at 5 miles per hour down a river which flows at 5 miles per hour will take 60 minutes to go 10 miles downstream (54%).

321. A body covering of feathers is a characteristic of birds but of no other animals (52%). Slightly more than a fourth of the 17s thought the "ability to fly" was a distinguishing characteristic (27%).

322. The highly efficient use of food by the body may explain why a person who is a light eater tends to be overweight (49%). A fifth of the 17s thought "a tendency toward nervousness" would be an acceptable explanation (20%).

323. The purpose of a fuse in an electric circuit is to prevent possible damage to the circuit (49%).

324. C above middle C has a higher frequency and shorter wavelength than middle C (46%).

325. The function of the placenta in a pregnant human female is to carry nourishment to the baby (41%). More than a fourth of the 17s said I-don't-know (27%).

326. Adding table salt to water results in the water's freezing at a lower temperature (36%). More than a fourth of the 17s thought it would result in the water's evaporating faster (28%).

327. Molecules of air carry sound to your ears from a radio or television receiver (35%). "Radio waves" was chosen by 39% of the 17s.

328. If the cells referred to were all in the same organism, the amount of DNA present would be identical in mature egg and sperm cells (34%). Almost half of the 17s said they didn't know the correct response (45%).

Rather few of the 17s responded correctly to the following exercises:

329. If two light waves are travelling in a vacuum, the wave with the higher frequency will have the shorter wavelength (32%). A fifth of the 17s said they didn't know (21%), and 23% chose the incorrect response, "longer wavelength."

330. On the average, in human females the egg is released 14 days after menstruation begins (29%). A quarter of the 17s chose "2 days," and 18% said they didn't know.

331. Under conditions specified in the exercise, the resistance of a resistor X is 5 ohms (25%). Almost half of the 17s said they didn't know the correct answer (48%).

332. Scientists can determine the age of certain rocks and their fossils by measuring the amounts of uranium and lead they contain (21%). Each of three other choices and the I-don't-know response also were chosen by about 20% of the 17s.

333. Experiments in which subatomic particles were shot at metal foil showed that atomic nuclei are more dense than the rest of the atom (18%). More than half the 17s said they didn't know (54%).

334. A substance synthesized in one part of the cell and then later broken down in other parts with a resulting release of energy is ATP (17%).

335. Uranium-lead dating has been used to obtain accurate estimates of the age of the oldest known rock strata (9%). A fourth of the 17s chose "radiocarbon dating" as the correct response, and 38% chose "correlation of age of fossils contained in the strata."

336. Tin and sulfur are oxidized from elements given in an equation (6%). The I-don't-know alternative was used by 41% of the 17s.

337. Metal cans for holding foodstuffs are chiefly made of iron (3%). More than 90% of the respondents thought metal cans are chiefly made of tin (93%).

338. Given the conditions of a horizontal wire extending in the north-south direction and a compass placed directly beneath the wire pointing east, it would be most reasonable to infer that electrons are flowing north in the wire (3%). Thirty percent of the 17s chose the incorrect response, "the wire is magnetized," and 31% chose I-don't-know.

EXERCISE 301

(17: 5-3) (similar to Exercise 401)

Which of the following groups of animals and plants would be found in a desert community?

Age 17		
0 %	O	Ground hogs, deer, oak, fern
0	O	Grizzly bears, buffaloes, fir, grass
0	O	Ducks, herons, water lilies, cattails
0	O	Starfish, sand dollars, kelp, plankton
98	●	Snakes, road runners, cactus, sagebrush
0	O	I don't know.
0		No response
98 %		

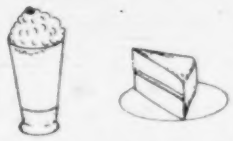
EXERCISE 302

(17: 6-3) (overlaps Exercise 204)

Which of the following would most closely represent a balanced meal?

Age 17

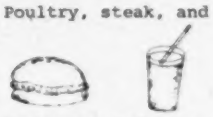
95 % ● Steak, bread, carrots, and milk



0 O Ice - cream soda and cake

3 O Potatoes, oatmeal, bread, and bananas

1 O Poultry, steak, and fish



1 O Hamburger and coke

0 O I don't know.

0 No response

100 %

EXERCISE 303

(17: 7-4)

At the present time nearly all gasoline comes from

Age 17		
4 %	O	coal.
93	●	petroleum.
0	O	water.
0	O	wood.
2	O	I don't know.
0		No response
99 %		

EXERCISE 304

(17: 10-10)

Which of the following animals that have been found as fossils in rocks have NEVER been seen alive by man?

Age 17		
89 %	●	Dinosaurs
1	O	Horses
5	O	Locusts
1	O	Oysters
1	O	Shrimp
3	O	I don't know.
0		No response
100 %		

EXERCISE 305

(17: 8-1) (overlaps Exercise 212) (similar to Exercise 403)

Information about which one of the following is most important in predicting weather?

Age 17		
1 %	O	The available supplies of water
9	O	The daily extremes of humidity
1	O	The daily extremes of wind speed
9	O	The daily extremes of temperature
77	●	The movement and characteristics of air masses
4	O	I don't know.
0		No response
101 %		

EXERCISE 306

(17: 6-16) (overlaps Exercise 417)

All of the following help to increase the total amount of food available to the human race EXCEPT

Age 17		
2 %	O	irrigating crops.
12	O	developing hybrids.
2	O	improving fertilizers.
70	●	outlawing the use of insecticides.
10	O	controlling the growth of undesirable plants.
4	O	I don't know.
0		No response
100 %		

EXERCISE 307

(17: 2-3)

Any galaxy contains many

Age 17		
2 %	O	moons.
22	O	planets.
5	O	satellites.
69	●	stars.
1	O	winds.
2	O	I don't know.
0		No response
101 %		

EXERCISE 308

(17: 5-5) (overlaps Exercise 410)

An electric current in a copper wire involves mainly the movement of

Age 17		
5 %	O	copper atoms.
10	O	copper molecules.
69	●	electrons.
3	O	neutrons.
2	O	protons.
11	O	I don't know.
0		No response
100 %		

EXERCISE 309

(17: 8-6) (overlaps Exercise 409)

The idea of natural selection is usually associated with the theory of evolution proposed by

Age 17		
68 %	●	Charles Darwin.
3	O	Edward Jenner.
2	O	Jean Lamarck.
7	O	Louis Pasteur.
1	O	Jonas Salk.
19	O	I don't know.
0		No response
100 %		

EXERCISE 310

(17: 11-1)

Changes such as the conversion of limestone to marble or of soft coal to hard coal are explained as having been brought about

Age 17		
12 %	O	by sudden cooling of the material.
1	O	by exposure to gases from a volcano.
1	O	by exposure to an underground river.
4	O	by the action of CO_2 from the atmosphere.
68	●	by heat and pressure below the Earth's surface.
14	O	I don't know.
0		No response
100 %		

EXERCISE 311

(17: 6-1) (overlaps Exercise 426)

The solid, liquid, and gaseous states of water differ in which of the following ways?

Age 17		
3 %	O	The number of protons per molecule
4	O	The number of electrons per molecule
4	O	The net charge on the individual molecules
5	O	The number of neutrons per individual molecule
65	●	The average speed with which the molecules are moving
20	O	I don't know.
0		No response
101 %		

EXERCISE 312

(17: 8-7)

Which of the following can be detected with unaided human eyes?

Age 17		
17 %	O	X-rays
3	O	Radio waves
7	O	Television waves
5	O	The Earth's magnetic field
61	●	Certain wavelengths of light
7	O	I don't know.
0		No response
100 %		

EXERCISE 313

(17: 9-9)

Research into the nature of matter shows that it is made up of

Age 17		
14 %	O	continuous uniform material.
9	O	uniform stationary particles.
58	●	individual moving particles.
2	O	smooth rolling disks.
2	O	rigid cubes.
14	O	I don't know.
0		No response
99 %		

EXERCISE 314

(17: 6-4) (similar to Exercise 222)

In terms of the theory of natural selection, what is the explanation of why giraffes have come to have such long necks?

Age 17		
12 %	O	Stretching to get food in high trees has made their necks longer.
1	O	There is something inside of giraffes which keeps making longer necks.
6	O	Giraffe food contained vitamins which caused the vertebrae to lengthen.
13	O	Giraffe necks have gotten longer and longer as time has gone on, but nobody has any idea why this is.
58	●	Giraffes born with the longest necks have been able to stay alive when food was scarce and have passed this trait on to their offspring.
10	O	I don't know.
0		No response
100 %		

EXERCISE 315

(17: 7-12)

If 2 pints of water at 40 °F are mixed with a pint of water at 100 °F, the temperature of the mixture immediately after mixing will be about

Age 17		
2 %	O	40 °F.
8	O	50 °F.
57	●	60 °F.
15	O	80 °F.
3	O	100 °F.
14	O	I don't know.
0		No response
99 %		

EXERCISE 316

(17: 10-2) (overlaps Exercise 406)

Which of the following acts as a stimulant to the heart?

Age 17		
56 %	●	Adrenaline
16	O	Alcohol
2	O	Aspirin
9	O	Barbiturates
6	O	Penicillin
10	O	I don't know.
0		No response
99 %		

EXERCISE 317

(17: 8-11) (similar to Exercise 218)

Mercury can be enclosed in glass to make a thermometer because mercury

Age 17		
8 %	o	is a metal.
5	o	is more dense than glass.
11	o	conducts heat better than glass.
9	o	has a higher specific heat than glass.
56	●	expands more than glass when both are heated together.
11	o	I don't know.
0		No response
100 %		

EXERCISE 318

(17: 3-2)

For most chemical changes, which of the following most nearly describes what occurs?

Age 17		
4 %	o	Atoms are formed from energy.
17	o	Atoms are converted into energy.
54	●	Atoms are rearranged into new molecules.
4	o	Molecules are formed from energy.
9	o	Molecules are converted into energy.
13	o	I don't know.
0		No response
101 %		

EXERCISE 319

(17: 9-12) (overlaps Exercise 418)

A 5-pound rock is dropped from a cliff 500 feet high. The longer the rock falls, the greater is its

Age 17		
17 %	o	acceleration.
18	o	potential energy.
54	●	speed
6	o	total energy.
3	o	volume.
3	o	I don't know.
0		No response
101 %		

EXERCISE 320

(17: 6-10) (overlaps Exercise 415)

A motor boat can travel 5 miles per hour on a still lake. If this boat travels downstream on a river that is flowing 5 miles per hour, how long will it take the boat to reach a bridge that is 10 miles downstream?

Age 17		
13 %	o	15 min.
16	o	30 min.
6	o	45 min.
54	●	60 min.
4	o	75 min.
8	o	I don't know.
0		No response
101 %		

EXERCISE 321

(17: 11-2) (overlaps Exercise 223)

Which of these is characteristic of birds but of no other animals?

Age 17		
27 %	O	Ability to fly
1	O	Ability to lay eggs
8	O	Tendency to migrate
52	●	Body covering of feathers
9	O	Regulated body temperature
3	O	I don't know.
1		No response
101 %		

EXERCISE 322

(17: 1-3) (overlaps Exercise 421)

If a person who is a light eater has a tendency to be overweight, it is most likely due to

Age 17		
1 %	O	too much exercise.
3	O	a carefully balanced diet.
20	O	a tendency toward nervousness.
15	O	an excessive dosage of vitamins.
49	●	highly efficient utilization of food by the body.
12	O	I don't know.
0		No response
100 %		

EXERCISE 323

(17: 7-5) (similar to Exercise 408)

The purpose of a fuse in an electric circuit is

Age 17		
13 %	O	to increase the current in the circuit.
14	O	to increase the voltage across the circuit.
9	O	to decrease the resistance of the circuit.
49	●	to prevent possible damage to the circuit.
2	O	to raise the temperature of the wires in the circuit.
13	O	I don't know.
0		No response
100 %		

EXERCISE 324

(17: 3-3)

The musical note middle C is sounded on a violin string, and then C one octave higher is sounded on the same string. Which of the following is correct in comparing the two notes?

Age 17		
13 %	O	Both have the same frequency but different wavelengths.
10	O	Both have the same frequency but different amplitudes.
9	O	Middle C has a higher frequency and longer wavelength.
46	●	Upper C has a higher frequency and shorter wavelength.
22	O	I don't know.
0		No response
100 %		

EXERCISE 325

(17: 1-6) (overlaps Exercise 420)

What is the function of the placenta in a pregnant human female?

Age 17		
5 %	O	To push the baby out at birth
8	O	To keep the baby warm and moist
41	●	To carry nourishment to the baby
13	O	To cushion the baby against shocks
5	O	To keep the baby's body temperature constant
27	O	I don't know.
0		No response
99 %		

EXERCISE 326

(17: 9-4)

Adding table salt to water results in the water's

Age 17		
36 %	●	freezing at a lower temperature.
19	O	changing into its elements.
28	O	evaporating faster.
5	O	dissolving more air.
1	O	becoming radioactive.
12	O	I don't know.
0		No response
101 %		

EXERCISE 327

(17: 2-4)

What carries sound to your ears from a radio or television receiver 15 feet away?

Age 17		
8 %	O	Electric currents
35	●	Molecules of air
10	O	Polarized waves
39	O	Radio waves
7	O	I don't know.
0		No response
99 %		

EXERCISE 328

(17: 3-6) (overlaps Exercise 431)

If the cells referred to were all in the same organism, in which of the following is the amount of DNA present stated correctly?

Age 17		
34 %	●	It would be identical in mature egg and sperm cells.
3	O	It would be identical in sperm cells and liver cells.
6	O	It would be identical in a mature egg cell and a brain cell.
3	O	It would be half as much in a thyroid cell as in a liver cell.
10	O	It would be half as much in the fertilized egg as in a thyroid gland cell.
45	O	I don't know.
0		No response
101 %		

EXERCISE 329

(17: 7-10) (similar to Exercise 430)

Two light waves are traveling in a vacuum. The wave with the higher frequency will have the

Age 17		
14 %	o	higher speed.
3	o	lower speed.
23	o	longer wavelength.
32	●	shorter wavelength.
7	o	more nearly horizontal direction.
21	o	I don't know.
0		No response
100 %		

EXERCISE 330

(17: 9-8) (overlaps Exercise 416)

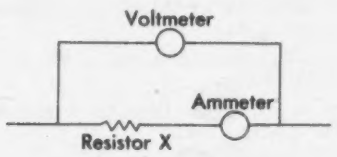
On the average, in human females, the egg is released how many days after menstruation begins?

Age 17		
25 %	o	2 days
12	o	9 days
29	●	14 days
4	o	20 days
11	o	24 days
18	o	I don't know.
1		No response
100 %		

EXERCISE 331

(17: 9-5)

In the section of the electric circuit shown below, the voltmeter registers 100 volts and the ammeter registers 20 amperes. If the connecting wires and the ammeter have negligible resistance, the resistance of resistor X is



Age 17		
1 %	o	1 ohm.
25	●	5 ohms.
5	o	10 ohms.
3	o	100 ohms.
18	o	2,000 ohms.
48	o	I don't know.
0		No response
100 %		

EXERCISE 332

(17: 7-7), (overlaps Exercise 433)

Scientists can determine the age of certain rocks and their fossils by measuring

Age 17		
3 %	o	their specific gravities.
18	o	their crystalline structure.
22	o	the rate at which they have eroded.
18	o	the ratio of calcium to phosphorus in them.
21	●	the amounts of uranium and lead they contain.
18	o	I don't know.
0		No response
100 %		

EXERCISE 333

(17: 9-3)

Experiments in which subatomic particles were shot at metal foil showed that atomic nuclei

Age 17		
3 %	o	rotate counterclockwise.
11	o	are electrically neutral.
18	●	are more dense than the rest of the atom.
10	o	vibrate to and fro in simple harmonic motion.
3	o	are nearly as large as the atoms that contain them.
54	o	I don't know.
0		No response
99 %		

EXERCISE 334

(17: 7-3)

Which of these is synthesized in the mitochondria, then later broken down in the nucleus and endoplasmic reticulum, with a resulting release of energy?

Age 17		
17 %	●	ATP
19	o	DNA
13	o	RNA
4	o	Lysosome
3	o	Golgi body
44	o	I don't know.
0		No response
100 %		

EXERCISE 335

(17: 5-6) (overlaps Exercise 434)

Which of these has been used to obtain accurate estimates of the age of the oldest known rock strata?

Age 17		
25 %	o	Radiocarbon dating
9	●	Uranium-lead dating
2	o	Potassium-argon dating
11	o	Estimation of sedimentation rates
38	o	Correlation of age of fossils contained in the strata
15	o	I don't know.
0		No response
100 %		

EXERCISE 336

(17: 8-13)

In the equation below, which of the following elements are oxidized?

$SnS + 4HNO_3 \rightarrow S + SnO_2 + 4NO_2 + 2H_2O$

Age 17		
6 %	●	Tin and sulfur
18	o	Tin and nitrogen
11	o	Sulfur and oxygen
13	o	Oxygen and hydrogen
10	o	Nitrogen and oxygen
41	o	I don't know.
0		No response
99 %		

EXERCISE 337

(17: 9-2)

Metal cans for holding foodstuffs are chiefly made of

Age 17		
2 %	O	copper.
3	●	iron.
1	O	nickel.
93	O	tin.
1	O	I don't know.
0		No response
100%		

EXERCISE 338

(17: 6-7)

A horizontal wire extends in the north-south direction. When a compass is placed directly beneath the wire, the compass needle turns and points east. It would be most reasonable to infer that

Age 17		
3 %	●	electrons are flowing north in the wire.
5	O	electrons are flowing south in the wire.
30	O	the wire is magnetized.
13	O	the wire is positively charged.
17	O	the wire is negatively charged.
31	O	I don't know.
0		No response
99%		

Age 17

Objective II. Possess the Abilities and Skills Needed to Engage in the Processes of Science

General Summary

The exercises under this objective require a respondent to use scientific apparatus, interpret data given to him, and explain certain natural occurrences. The 17s were able to show these abilities and skills with varying degrees of success.

Most 17s could:

339. Give two or three reasons why the engine of a car which had stopped running would not start again (85%).

340. Interpret tabular data to correctly determine which series of four weights best establishes that one object is heavier than another (81%).

341. Balance a beam balance with a weight (75%).

342. Recognize that disturbing the balance between hawks, rabbits, and grass in a particular meadow by decreasing the number of rabbits will also affect the number of hawks and the amount of the grass (68%). A fifth of the 17s did not think upsetting the balance would affect other parts of the system (20%).

A good many 17s, when presented with exercises calling for the following i formation, could:

343. Pick a theoretical statement out of a set in which the other statements are facts or opinions; (59% selected the correct statement "mesons account for the stability of the nuclei of platinum atoms").

344. Time the operation of a pendulum accurately (56%).

345. Pick a statement regarding conservation of matter as the best explanation of the remark, "Some carbon atoms in the bread that I ate last night might have once been part of a dinosaur's body" (40%).

Rather few of the 17s gave the correct response to the following exercises:

346. If the linear dimensions of a cube-shaped cell were doubled, its volume would increase 8 times (33%).

347. Explain why a flask loses weight daily when it is planted with corn and stoppered with a one-hole stopper (18% selected the hypothesis that seedlings use starch in the seeds and give off gases that escape; 29% said I-don't-know).

348. Determine the density of a wood block given various bits of appropriate information (12%).

EXERCISE 339

(17: 13 - 20b)

b. A car stops at a traffic light and the engine stops running. The engine will not start again. Suggest three reasons why it will not start again.

Age 17

Number of acceptable responses

no	%
1	11
2	36
3	49
	100 %

1. _____
_____
_____
_____
2. _____
_____
_____
_____
3. _____
_____
_____
_____

A response was scored successful if two or three reasons were given.

(continued on next page)

EXERCISE 339
(continued)

(17: 13-20b)

Only the first three reasons given by the assessee are to be considered.

Acceptable reasons (1 point is given for each of these up to a total of 3):

1. No gas
2. Battery faulty
3. Starter motor faulty
4. Engine (carburetor, cylinders) flooded
5. Sparkplugs faulty
6. Break in an electrical circuit
7. Fuel line blocked
8. Idle setting improper
9. Clutch not depressed
10. Engine cold
11. Vapor lock
12. Key stuck in ignition switch
13. Points faulty
14. Engine wet
15. Carburetor faulty
16. Distributor faulty
17. Choke stuck
18. Generator faulty
19. Engine (pistons) frozen

Unacceptable reasons (no points):

1. Original reason for stopping persists
2. Car in such condition that it won't start
3. Transmission won't go into fifth gear
4. Some part of engine has failed
5. Incompetent driver
6. Lousy car
7. Car has stalled
8. Engine has burned out
9. Engine dead
10. Engine won't turn over
11. Bad engine
12. Engine blew up
13. Car needs tune-up

EXERCISE 340

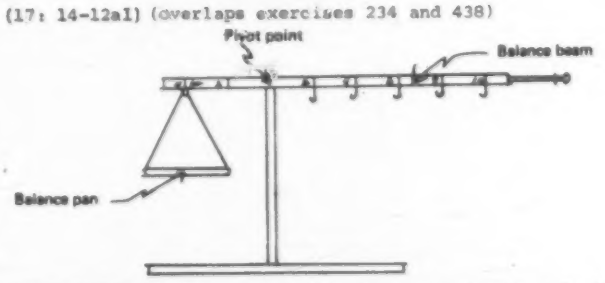
(17: 1-1) (overlaps exercises 235 and 439)

In each of five experiments, two objects were weighed four times each. Which experiment gives the strongest evidence that object I weighs more than object II?

Age 17			Object I	Object II
81 %	●	Experiment A	80 lb.	70 lb.
			81 lb.	69 lb.
			80 lb.	71 lb.
			82 lb.	70 lb.
4	O	Experiment B	69 lb.	81 lb.
			71 lb.	82 lb.
			70 lb.	80 lb.
			70 lb.	80 lb.
1	O	Experiment C	70 lb.	80 lb.
			75 lb.	75 lb.
			77 lb.	73 lb.
			80 lb.	70 lb.
1	O	Experiment D	80 lb.	70 lb.
			75 lb.	75 lb.
			73 lb.	77 lb.
			70 lb.	80 lb.
5	O	Experiment E	80 lb.	77 lb.
			79 lb.	76 lb.
			78 lb.	75 lb.
			77 lb.	74 lb.
5	O	I don't know.		
2		No response		
99 %				

EXERCISE 341

(17: 14-12a1) (overlaps exercises 234 and 438)



The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

1. Place one weight in the balance pan. How many inches from the pivot point is the hook on which you must hang one weight to get balance? ___(4)___

Age 17	
75 %	Correct
22	Incorrect
2	No response
99 %	

The apparatus also included fishweights, one to place in the balance pan, and another to use to achieve balance. The respondent was given 20 minutes to find the answer to this and other questions involving the use of the apparatus (see Exercise 348).

EXERCISE 342

(17: 5-8) (overlaps Exercise 440)

In a particular meadow there are many rabbits that eat the grass. There are also many hawks that eat the rabbits. Last year a disease broke out among the rabbits and a great number of them died. Which of the following probably then occurred?

Age 17		
4 %	O	The grass died and the hawk population decreased.
1	O	The grass died and the hawk population increased.
68	●	The grass grew taller and the hawk population decreased.
4	O	The grass grew taller and the hawk population increased.
20	O	Neither the grass nor the hawks were affected by the death of the rabbits.
2	O	I don't know.
1		No response
100 %		

EXERCISE 343

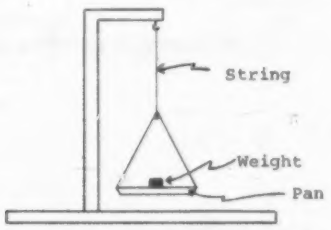
(17: 2-7)

Which of the following is a theory rather than a fact or an opinion about platinum?

Age 17		
5 %	O	Platinum is a metal.
5	O	Platinum is more dense than water.
8	O	Platinum is the most beautiful metal.
12	O	Wedding bands should be made of platinum.
59	●	Mesons account for the stability of the nuclei of platinum atoms.
11	O	I don't know.
0		No response
100 %		

EXERCISE 344

(17: 14-12c1) (overlaps exercises 237 and 441)



The apparatus before you is a pendulum. You have a watch or clock also.

1. How long does it take for the weight in the pan on the end of the string to swing back and forth ten times? _____ seconds (An answer between 11 and 15 seconds was scored correct.)

Age 17	
56 %	Correct
41	Incorrect
3	No response
100 %	

EXERCISE 345

(17: 3-4) (overlaps Exercise 443)

A student made the following statement, "Some carbon atoms in the bread that I ate last night might have once been part of a dinosaur's body."
Which of the following is the best appraisal of the student's statement? This statement

Age 17		
6 %	O	contradicts the law of conservation of matter.
2	O	is ridiculous because dinosaurs lived so long ago.
40	●	could be true because atoms are rarely created or destroyed.
24	O	could be true only if the bread was grown in soil containing dinosaur fossils.
15	O	could not possibly be true because dinosaurs were animals but wheat is a plant.
11	O	I don't know.
0		No response
98 %		

EXERCISE 346

(17: 5-14) (overlaps Exercise 444)

A particular cell is shaped like a cube. If all its linear dimensions were doubled, its volume would increase

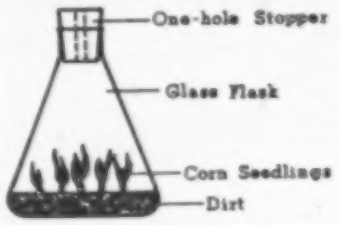
Age 17

5 %	O	3 times.
22	O	4 times.
15	O	6 times.
33	●	8 times.
16	O	16 times.
9	O	I don't know.
0		No response
100 %		

EXERCISE 347

(17: 11-3)

Corn is planted in a flask as shown below. The flask is weighed each day for three weeks. The flask shows a daily weight loss. Which of the following is the best explanation of this loss of weight?

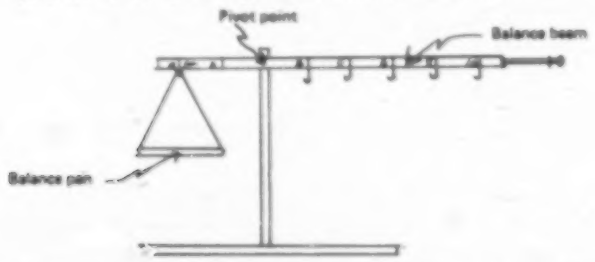


Age 17

17 %	O	The original water evaporates within the first day.
11	O	Carbon dioxide is lighter in weight than ordinary air.
8	O	Seed material is changed to leaves and roots that weigh less.
18	●	The seedlings use starch in the seeds and give off gases that escape.
16	O	Dry air enters through the stopper and replaces the moist air in the flask.
29	O	I don't know.
0		No response
99 %		

EXERCISE 348

(17: 14-12a5) (overlaps exercises 240 and 445)



The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

(The apparatus also included 10-gram fishweights, a centimeter ruler, and a block of wood 10 x 3 x 2 centimeters. Respondents were given 20 minutes to answer several related questions (e.g., see Exercise 341). The following question was preceded by others which required them to make measurements which would assist them in answering it.)

5. What is the density of the wood block? It is _____ grams per cubic centimeter. (An answer between .38 and .64 was scored correct.)

Age 17

12 %	Correct
63	Incorrect
25	No response
100 %	

Age 17

Objective III. Understand the Investigative Nature of Science

General Summary

Three multiple-choice exercises are released. Two of them most 17s answered correctly but rather few answered the third correctly.

349. Most 17s identified mathematics as useful in scientific research (92%).

350. Most indicated understanding that measurement is not exact (72%). About a fifth incorrectly chose the response, "all of the measurements will be exactly the same" (19%).

351. Rather few selected the kinetic-molecular theory as a generalization of the gas laws of Boyle, Charles and Graham (29%). Almost half said I-don't-know (47%).

EXERCISE 349

(17: 3-5) (overlaps Exercise 241)

Skill in which of the following is most useful in scientific research?

Age 17		
1%	O	Music
1	O	Magic
1	O	Marketing
92	●	Mathematics
4	O	Manufacturing
1	O	I don't know.
0		No response
100%		

EXERCISE 350

(17: 4-7) (overlaps exercises 243 and 446)

Whenever scientists carefully measure any quantity many times, they expect that

Age 17		
19%	O	all of the measurements will be exactly the same.
2	O	only two of the measurements will be exactly the same.
3	O	all but one of the measurements will be exactly the same.
72	●	most of the measurements will be close but not exactly the same.
3	O	I don't know.
0		No response
99%		

EXERCISE 351

(17: 2-5)

Boyle's law, Charles' law, and Graham's law dealing with the behavior of gases can all be generalized in terms of which of the following?

Age 17		
8%	O	Quantum theory
4	O	Recapitulation theory
5	O	Bohr theory of the atom
29	●	Kinetic-molecular theory
7	O	Theory of natural selection
47	O	I don't know.
0		No response
100%		

Objective IV. Have Attitudes about and Appreciations of Scientists, Science, and the Consequences of Science that Stem from Adequate Understandings

General Summary

There are just three exercises released for this objective.

When presented with the following exercises, most 17s:

352. Recognized that scientists want to know more about the world (81%).

353. Recognized that United States scientists are not ahead of scientists in other countries in every field of research (76%).

Rather few 17s indicated:

354. They usually look at special television programs on scientific topics (17%). However, 64% indicated they would watch such a program "sometimes."

EXERCISE 352

(17: 11-4)

Most scientists

Age 17		
81 %	●	want to know more about the world.
1	O	plan experiments as hastily as possible.
4	O	believe that some things happen without causes.
3	O	permit likes and dislikes to outweigh their observations.
7	O	use facts gathered by their own experiments and observations and pay no attention to results of others.
4	O	I don't know.
0		No response
100 %		

EXERCISE 353

(17: 4-8) (overlaps Exercise 448)

United States scientists are ahead of scientists in other countries in every field of research.

Age 17		
17 %	O	I believe this statement.
76	●	I don't believe this statement.
7	O	I don't know.
0		No response
100 %		

EXERCISE 354

(17: 11-10a) (overlaps Exercise 449)

(a) If you learn about a special television program dealing with a scientific topic, do you watch it?

Age 17		
17 %	●	Often
64	O	Sometimes
19	O	Never
0	O	I don't know.
1		No response
100 %		

Young Adults

Objective I. Know Fundamental Facts and Principles of Science

General Summary

All of the Adult exercises for Objective I were multiple-choice. Young adults use the I-don't-know response rather often. Even for one of the easy exercises (consequences of sterilizing an adult male) over 20% responded I-don't-know while 72% were answering correctly. For the seven difficult exercises released here, from 32% to 71% responded I-don't-know. This suggests that many Adults know they lack knowledge of specific scientific facts or are apt not to respond when they are not certain of their knowledge.

The seven released exercises that were answered correctly by most Adults deal with non-technical information that might be found in newspaper or magazine articles dealing with scientific topics or in television programs on science. Five of the seven might be considered to have to do with biology or medicine.

The 20 released exercises that were answered correctly by a good many Adults (between 34% and 67%) are heterogeneous in content. Some might be classified in the area of general knowledge (purpose of a fuse) and others call for formal education (flower seeds develop from ovules).

The exercises that few Adults answered correctly are quite technical in nature, involving knowledge that is likely to be learned only in school and is reinforced by experience by few young adults (e.g. the periodic table).

Most young adults responded correctly:

401. Snakes, road runners, cactus, and sagebrush would be found in a desert (95%).

402. The sex of a human baby is determined by chromosomes (91%).

403. The movement and characteristics of air masses are important in predicting weather (85%).

404. A malady that cannot be inherited is whooping cough (79%).

405. Sterilizing an adult human male by "tying off" his main sperm ducts will not result in any of the following: 1) his voice becoming higher pitched, 2) fatty pads on his hips, 3) effeminate behavior, or 4) longer growth of hair (72%).

406. Adrenaline acts as a stimulant (70%).

407. In mammals sperm is produced by the testes (67%).

A good many young adults responded correctly that:

408. A fuse is placed in an electric circuit to make the circuit safer (64%).

409. The theory of evolution through natural selection is associated with Charles Darwin (63%); 30% responded I-don't-know.

410. An electric current in a copper wire involves mainly the movement of electrons (63%). About 30% responded I-don't-know.

411. Flower seeds develop from ovules (62%).

412. Physical rejection of an organ transplanted is least likely if the donor is an identical twin (60%).

413. Most of the chemical energy of the gasoline burned in a car is converted to heat (60%).

414. Salt carried by the rivers to the oceans comes from beneath the ground (57%).

415. If a motor boat which can travel 5 miles per hour on a still lake travels downstream on a river that is flowing 5 miles per hour it will take the boat 60 minutes to reach a bridge that is 10 miles downstream (56%).

416. The egg of the human females is released about 14 days after menstruation begins (55%).

417. One could not increase the total amount of food available by outlawing insecticides (55%).

418. The longer a rock falls, the greater is its speed (51%).

419. The molecules of hot water are moving faster than the molecules of cold water (49%). Over 30% responded I-don't-know.

420. Placenta in a pregnant human female carries nourishment to the baby (45%).

421. If a person who is a light eater has a tendency to be overweight, it is most likely due to highly efficient utilization of food by the body (45%).

422. Most caves are formed by the action of underground water on limestone (42%).

423. The system of classifying plants and animals that is most commonly used in the biological sciences is based primarily on structure (42%).

424. Bacteria do NOT play a key role in photosynthesis (40%); 24% responded I-don't-know.

425. If a fossil of an ocean fish is found in a rock outcrop on a mountain it probably means that the mountain was raised up after the fish died (39%).

426. The chief difference between solid, liquid, and gaseous states of water is the speed with which molecules are moving (37%). Over 50% responded I-don't-know.

427. In mammals the cerebrum is the center of memory and intelligence (36%).

Rather few young adults responded correctly that:

428. If a man whose blood type is OA marries a woman whose blood type is OB, their offspring could NOT have AA blood type (31%); 50% responded I-don't-know.

429. The table showing relations among all the chemical elements is called the periodic table (26%); 45% responded I-don't-know.

430. If two light waves are travelling in a vacuum the wave with the higher frequency will have the shorter wavelength (22%). Over 40% responded I-don't-know.

431. The amount of DNA is identical in a mature egg cell and sperm cell within the same organism (21%). Over 65% responded I-don't-know.

432. The atomic weight of titanium is 48. This means that the average mass of titanium atoms is approximately 4 times the mass of the atoms of a certain carbon isotope with atomic mass 12 (16%). Over 70% responded I-don't-know.

433. Scientists can determine the age of certain rocks and their fossils by measuring the amounts of uranium and lead they contain (15%). Over 30% responded I-don't-know.

434. Uranium-lead dating has been used to obtain accurate estimates of the age of the oldest known rock strata (3%). Over 40% responded I-don't-know.

EXERCISE 401

(Adult: 2-14) (similar to Exercise 301)

Which of the following groups of animals and plants would be found in a desert community?

Adult		
1%	O	Ground hogs, deer, oak, fern
1	O	Grizzly bears, buffaloes, fir, grass
0	O	Ducks, herons, water lilies, cattails
95	●	Snakes, road runners, cactus, sagebrush
1	O	Starfish, sand dollars, kelp, plankton
1	O	I don't know.
1		No response
100%		

EXERCISE 402

(Adult: 3-9)

The sex of a human baby is determined by which of the following?

Adult		
≥1%	O	The length of the pregnancy
0	O	The mother's diet during pregnancy
1	O	The thoughts and wishes of the mother
91	●	Certain chromosomes in the fertilized egg
1	O	The kinds of activities in which the mother participates during pregnancy
4	O	I don't know.
1		No response
99%		

EXERCISE 403

(Adult: 2-12) (similar to exercises 212 and 305)

Information about which one of the following is most important in predicting weather?

Adult		
3%	O	The daily extremes of temperature
3	O	The daily extremes of humidity
1	O	The daily extremes of wind speed
2	O	The available supplies of water
85	●	The movement and characteristics of air masses
5	O	I don't know.
1		No response
100%		

EXERCISE 404

(Adult: 1-11)

All of the following can be inherited EXCEPT

Adult		
7%	O	color blindness.
2	O	diabetes.
0	O	hemophilia.
4	O	mongolism.
79	●	whooping cough.
6	O	I don't know.
1		No response
99%		

EXERCISE 405

(Adult: 10-11)

Adult human males can be sterilized by "tying off" both of their main sperm ducts in a simple operation. As a consequence, which of these will occur?

Adult		
3 %	o	The voice will eventually become high pitched.
1	o	Fatty pads will gradually develop on the hips.
3	o	Behavior will eventually become more effeminate.
0	o	The hair will develop in longer strands than usual.
72	•	None of the above will occur.
21	o	I don't know.
1		No response
101 %		

EXERCISE 406

(Adult: 6-20) (overlaps Exercise 316)

Which of the following acts as a stimulant to the heart?

Adult		
70 %	•	Adrenaline
12	o	Alcohol
1	o	Aspirin
6	o	Barbiturates
3	o	Penicillin
6	o	I don't know.
2		No response
100 %		

EXERCISE 407

(Adult: 9-17)

Which of the following organs in mammals produces sperm?

Adult		
7 %	o	Adrenal glands
2	o	Kidneys
0	o	Liver
4	o	Pancreas
67	•	Testes
18	o	I don't know.
2		No response
100 %		

EXERCISE 408

(Adult: 1-13) (similar to Exercise 323)

The purpose of a fuse in an electric circuit is

Adult		
1	o	to raise the temperature of the wires in the circuit.
7	o	to increase the voltage across the circuit.
8	o	to increase the current in the circuit.
5	o	to decrease the electrical resistance.
64	•	to make the circuit safer.
14	o	I don't know.
0		No response
99 %		

EXERCISE 409

(Adult: 3-12) (overlaps Exercise 309)

The idea of natural selection is usually associated with the theory of evolution proposed by

Adult		
63 %	●	Charles Darwin.
2	O	Edward Jenner.
1	O	Jean Lamarck.
3	O	Louis Pasteur.
0	O	Jonas Salk.
30	O	I don't know.
1		No response
100 %		

EXERCISE 410

(Adult: 4-12) (overlaps Exercise 308)

An electric current in a copper wire involves mainly the movement of

Adult		
2	O	copper atoms.
4	O	copper molecules.
63	●	electrons.
1	O	neutrons.
1	O	protons.
28	O	I don't know.
1		No response
100 %		

EXERCISE 411

(Adult: 8-19) (overlaps Exercise 215)

Flower seeds develop from

Adult		
1 %	O	leaves.
62	●	ovules.
10	O	petals.
8	O	roots.
4	O	stems.
12	O	I don't know.
2		No response
99 %		

EXERCISE 412

(Adult: 3-15)

In organ transplant surgery, i.e., kidney, heart, liver, the rejection of the transplanted organ by the tissues of the receiver would be LEAST likely to occur if the donor were

Adult		
60 %	●	an identical twin.
3	O	the mother of the receiver.
6	O	a brother with different RH blood group.
0	O	a sister not older by more than three years.
14	O	a fraternal twin with the same blood group.
15	O	I don't know.
1		No response
99 %		

EXERCISE 413

(Adult: 9-19) (similar to Exercise 217)

Most of the chemical energy of the gasoline burned in a car is not used to move the car but is converted into

Adult		
14 %	o	electricity.
60	●	heat.
0	o	light.
4	o	magnetism.
4	o	sound.
16	o	I don't know.
2		No response
100 %		

EXERCISE 414

(Adult: 6-16)

Most of the salt carried each year by the rivers to the oceans comes from

Adult		
4 %	o	the sky.
5	o	condensed dew.
6	o	melted glaciers.
57	●	beneath the ground.
1	o	the North Pole or the South Pole.
27	o	I don't know.
2		No response
102 %		

EXERCISE 415

(Adult: 3-16) (overlaps Exercise 320)

A motor boat can travel 5 miles per hour on a still lake. If this boat travels downstream on a river that is flowing 5 miles per hour, how long will it take the boat to reach a bridge that is 10 miles downstream?

Adult		
11 %	o	15 min.
11	o	30 min.
5	o	45 min.
56	●	60 min.
3	o	75 min.
14	o	I don't know.
1		No response
101 %		

EXERCISE 416

(Adult: 7-22) (overlaps Exercise 330)

On the average, in human females, the egg is released how many days after menstruation begins?

Adult		
12 %	o	2 days
12	o	9 days
55	●	14 days
4	o	20 days
5	o	24 days
11	o	I don't know.
1		No response
100 %		

EXERCISE 417

(Adult: 3-7) (overlaps Exercise 306)

All of the following help to increase the total amount of food available to the human race EXCEPT

Adult		
2 %	O	irrigating crops.
12	O	developing hybrids.
2	O	improving fertilizers.
55	●	outlawing the use of insecticides.
17	O	controlling the growth of undesirable plants.
10	O	I don't know.
1		No response
99 %		

EXERCISE 418

(Adult: 4-20) (overlaps Exercise 319)

A 5-pound rock is dropped from a cliff 500 feet high. The longer the rock falls, the greater is its

Adult		
18 %	O	acceleration.
12	O	potential energy.
51	●	speed.
7	O	total energy.
3	O	volume.
8	O	I don't know.
1		No response
100%		

EXERCISE 419

(Adult: 4-20) (overlaps Exercise 211)

Which of the following is true of hot water as compared with cold water?

Adult		
6 %	O	It is denser.
2	O	It is easier to see through.
87	●	Its molecules are moving faster.
1	O	It has more free oxygen dissolved in it.
0	O	It has more free hydrogen dissolved in it.
11	O	I don't know.
1		No response
99 %		

EXERCISE 420

(Adult: 1-17) (overlaps Exercise 325)

What is the function of the placenta in a pregnant human female?

Adult		
3 %	O	To push the baby out at birth
5	O	To keep the baby warm and moist
45	●	To carry nourishment to the baby
16	O	To cushion the baby against shocks
4	O	To keep the baby's body temperature constant.
27	O	I don't know.
1		No response
101 %		

EXERCISES 421

(Adult: 2-15) (overlaps Exercise 322)

If a person who is a light eater has a tendency to be overweight, it is most likely due to

Adult		
1 %	O	too much exercise.
3	O	a carefully balanced diet.
22	O	a tendency toward nervousness.
6	O	an excessive dosage of vitamins.
45	●	highly efficient utilization of food by the body.
20	O	I don't know.
2		No response
99 %		

EXERCISE 422

(Adult: 2-20) (overlaps Exercise 221)

Most caves are formed by the action of underground water on

Adult		
9 %	O	granite.
42	●	limestone.
1	O	pumice.
16	O	sandstone.
4	O	shale.
27	O	I don't know.
1		No response
100 %		

EXERCISE 423

(Adult: 2-16)

The system of classifying plants and animals that is most commonly used in the biological sciences is based primarily on

Adult		
8 %	O	food habits.
15	O	function.
18	O	geographical location.
2	O	size.
42	●	structure.
14	O	I don't know.
2		No response
101 %		

EXERCISE 424

(Adult: 1-16)

Bacteria play a key role in all of the following EXCEPT

Adult		
4 %	O	fermentation.
40	●	photosynthesis.
4	O	causing disease.
24	O	nitrogen-fixation.
3	O	the decay of dead plants and animals.
24	O	I don't know.
1		No response
100 %		

EXERCISE 425

(Adult: 6-11) (overlaps Exercise 228)

A fossil of an ocean fish was found in a rock outcrop on a mountain. This probably means that

Adult		
4 %	O	fish once lived on the mountain.
1	O	the relative humidity was once very high.
39	●	the mountain was raised up after the fish died.
4	O	fish used to be amphibians like toads and frogs.
41	O	the fossil fish was probably carried to the mountain by a great flood.
10	O	I don't know.
1		No response
100 %		

EXERCISE 426

(Adult: 10-18) (overlaps Exercise 311)

The solid, liquid, and gaseous states of water differ in which of the following ways?

Adult		
1 %	O	The number of protons per molecule
1	O	The number of electrons per molecule
3	O	The net charge on the individual molecules
2	O	The number of neutrons per individual molecule
37	●	The average speed with which the molecules are moving
53	O	I don't know.
2		No response
99 %		

EXERCISE 427

(Adult: 7-11) (overlaps Exercise 227)

In mammals, which of the following is the center of memory and intelligence?

Adult		
27 %	O	Cerebellum
36	●	Cerebrum
6	O	Medulla
4	O	Optic nerve
2	O	Spinal cord
24	O	I don't know.
1		No response
100 %		

EXERCISE 428

(Adult: 4-10)

A man whose blood type is OA marries a woman whose blood type is OB. Their offspring could NOT have which of the following blood types?

Adult		
31 %	●	AA
3	O	AB
1	O	OA
1	O	OB
12	O	OO
50	O	I don't know.
1		No response
99 %		

EXERCISE 429

(Adult: 7-14)

The table in which all of the chemical elements are arranged to show many relationships among them is called the

Adult		
9 %	O	activity table.
26	●	periodic table.
6	O	table of acid strengths.
4	O	table of electronegatives.
9	O	table of oxidation potentials.
45	O	I don't know.
1		No response
100 %		

EXERCISE 430

(Adult: 6-19) (similar to Exercise 329)

Two light waves are traveling in a vacuum. The wave with the higher frequency will have the

Adult		
2 %	O	lower speed.
15	O	higher speed.
13	O	longer wavelength.
22	●	shorter wavelength.
4	O	more nearly horizontal direction.
42	O	I don't know.
1		No response
99 %		

EXERCISE 431

(Adult: 5-20) (overlaps Exercise 328)

If the cells referred to were all in the same organism, in which of the following is the amount of DNA present stated correctly?

Adult		
21 %	●	It would be identical in mature egg and sperm cells.
1	O	It would be identical in sperm cells and liver cells.
6	O	It would be identical in a mature egg cell and a brain cell.
1	O	It would be half as much in a thyroid cell as in a liver cell.
2	O	It would be half as much in the fertilized egg as in a thyroid gland cell.
67	O	I don't know.
1		No response
99 %		

EXERCISE 432

(Adult: 10-14)

The atomic weight of titanium is 48. This means that the average mass of titanium atoms is approximately

Adult		
2 %	O	1/48 gram.
1	O	1 gram.
4	O	48 grams.
16	●	4 times the mass of the atoms of a certain carbon isotope with atomic mass 12.
5	O	48 times the mass of the atoms of a certain carbon isotope with atomic mass 12.
71	O	I don't know.
1		No response
100 %		

EXERCISE 433

(Adult: 1-14) (overlaps Exercise 332)

Scientists can determine the age of certain rocks and their fossils by measuring

Adult		
4 %	O	their specific gravities.
22	O	their crystalline structure.
17	O	the rate at which they have eroded.
10	O	the ratio of calcium to phosphorus in them.
15	●	the amounts of uranium and lead they contain.
32	O	I don't know.
0		No response
100%		

EXERCISE 434

(Adult: 8-18) (overlaps Exercise 335)

Which of these has been used to obtain accurate estimates of the age of the oldest known rock strata?

Adult		
22 %	O	Radiocarbon dating
2	●	Uranium-lead dating
3	O	Potassium-argon dating
5	O	Estimation of sedimentation rates
22	O	Correlation of age of fossils contained in the strata
43	O	I don't know.
1		No response
98 %		

Objective II. Possess the Abilities and Skills Needed to Engage in the Processes of Science

General Summary

Only 11 exercises were released under Objective II. Four were quite easy, three quite difficult, and four were of average difficulty. One cannot generalize from such small subsets of exercises.

Most young adults responded correctly that:

435. Very few people in the United States today get smallpox because most people have smallpox vaccinations (95%).

436. The most likely cause that paint on one side of a house is not lasting as well as paint on the other sides is wind or sun (94%).

437. A bar graph which was pictured could be read to obtain the information requested (89% read the graph correctly).

438. Most could balance a beam balance with a weight (74%).

A good many young adults were able to perform the following tasks:

439. Interpret tabular data to correctly determine which series of four weights best establishes that one object is heavier than another (63%).

440. Recognize that disturbing the balance between hawks, rabbits, and grass in a particular meadow by decreasing the number of rabbits will also affect the number of hawks and the amount of the grass (52%).

441. Use a watch to determine the total time it takes a pendulum to swing 10 times (49%).

442. Identify a graph showing a growth curve for height of children from age 2 to age 14 from a set of five graphs (39%).

Rather few young adults:

443. Realized that atoms are rarely destroyed so that carbon atoms in a piece of bread could have been part of a dinosaur's body in ages past (25%).

444. Knew that doubling the size of each dimension of a cube will increase its volume 8 times (25%).

445. Could determine the density of a wood block after being given various bits of appropriate information (12%).

EXERCISE 435

(Adult: 7-12) (overlaps Exercise 152)

Why do very few people get smallpox in the United States today?

Adult		
1%	o	The weather conditions have changed.
95	●	Most people get smallpox vaccinations.
0	o	People move more often than they used to.
0	o	People drink more milk today than ever before.
1	o	All the germs that cause smallpox have been killed.
1	o	I don't know.
1		No response
99%		

EXERCISE 436

(Adult: 5-19) (overlaps Exercise 230)

A man notices that the paint on one side of his house is not lasting as well as the paint on the other sides. Which of the following is the most likely cause?

Adult		
1%	o	Termites
2	o	Cosmic rays
94	●	Wind or sun
0	o	Fallout from atom bombs
0	o	Sonic booms from low-flying jets
1	o	I don't know.
1		No response
99%		

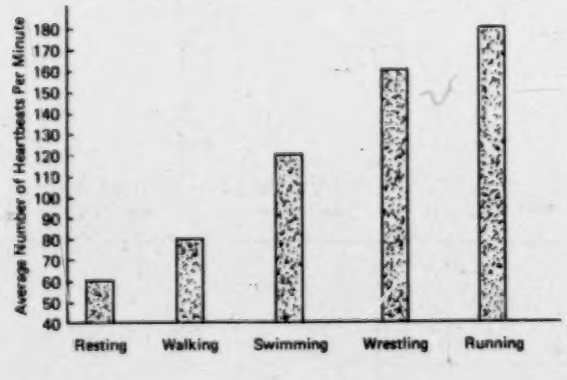
EXERCISE 437

(Adult: 6-15)

According to the graph below, what is the average number of heartbeats per minute for a person swimming?

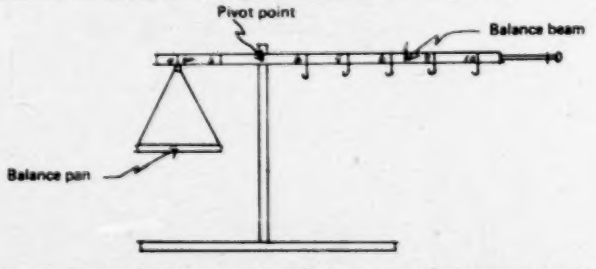
Adult		
1%	o	60
2	o	80
89	●	120
1	o	160
1	o	180
5	o	I don't know.
2		No response
101%		

AVERAGE NUMBER OF HEARTBEATS PER MINUTE IN DIFFERENT ACTIVITIES



EXERCISE 438

(Adult: 10-21al) (overlaps exercises 234 and 341)



The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

1. Place one weight in the balance pan. How many inches from the pivot point is the hook on which you must hang one weight to get balance? ____(4)____

Adult	
74%	Correct
20	Incorrect
6	No response
100%	

The apparatus also included fishweights, one to place in the balance pan, and another to use to achieve balance. The respondent was given 20 minutes to find the answer to this and other questions involving the use of the apparatus (see Exercise 445).

EXERCISE 439

(Adult: 1-7) (overlaps exercises 235 and 340)

In each of five experiments, two objects were weighed four times each. Which experiment gives the strongest evidence that object I weighs more than object II?

Adult			Object I	Object II
63 %	●	Experiment A	80 lb.	70 lb.
			81 lb.	69 lb.
			80 lb.	71 lb.
			82 lb.	70 lb.
7	O	Experiment B	69 lb.	81 lb.
			71 lb.	82 lb.
			70 lb.	80 lb.
			70 lb.	80 lb.
2	O	Experiment C	70 lb.	80 lb.
			75 lb.	75 lb.
			77 lb.	73 lb.
			80 lb.	70 lb.
2	O	Experiment D	80 lb.	70 lb.
			75 lb.	75 lb.
			73 lb.	77 lb.
			70 lb.	80 lb.
9	O	Experiment E	80 lb.	77 lb.
			79 lb.	76 lb.
			78 lb.	75 lb.
			77 lb.	74 lb.
15	O	I don't know.		
3		No response		
101 %				

EXERCISE 440

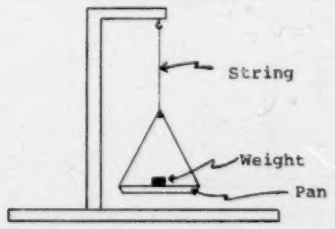
(Adult: 3-10) (overlaps Exercise 342)

In a particular meadow there are many rabbits that eat the grass. There are also many hawks that eat the rabbits. Last year a disease broke out among the rabbits and a great number of them died. Which of the following probably then occurred?

Adult		
2 %	O	The grass died and the hawk population decreased.
1	O	The grass died and the hawk population increased.
52	●	The grass grew taller and the hawk population decreased.
4	O	The grass grew taller and the hawk population increased.
30	O	Neither the grass nor the hawks were affected by the death of the rabbits.
10	O	I don't know.
1		No response
100 %		

EXERCISE 441

(Adult: 10-21cl) (overlaps exercises 237 and 344)



The apparatus before you is a pendulum. You have a watch or clock also.

1. How long does it take for the weight in the pan on the end of the string to swing back and forth ten times? _____ seconds (An answer between 11 and 15 seconds was scored correct.)

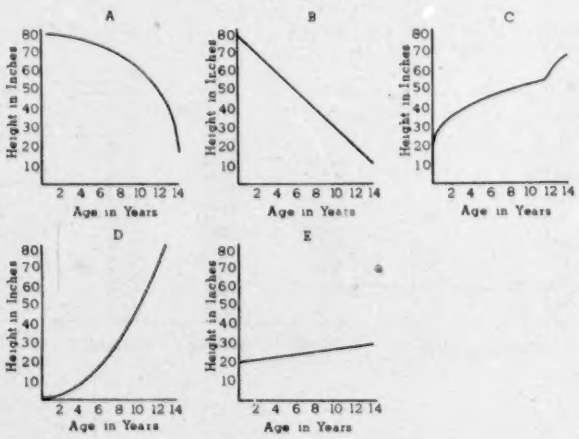
Adult	
49 %	Correct
39	Incorrect
12	No response
100 %	

EXERCISE 442

(Adult: 4-8) (similar to Exercise 239)

Which of the following graphs could show the average height in inches of a group of children growing at a normal rate plotted against their age in years?

Adult		
6 %	O	A
9	O	B
39	●	C
18	O	D
9	O	E
16	O	I don't know.
3		No response
100 %		



EXERCISE 443

(Adult: 8-15) (similar to Exercise 345)

A student made the following statement, "Some carbon atoms in the bread that I ate last night might have once been part of a dinosaur's body."
Which of the following is the best appraisal of the student's statement? This statement

Adult		
3 %	o	contradicts the law of conservation of matter.
5	o	is ridiculous because dinosaurs lived so long ago.
25	•	could be true because atoms are rarely created or destroyed.
7	o	could not possibly be true because dinosaurs were animals but wheat is a plant.
33	o	could be true only if the bread was grown in soil containing dinosaur fossils.
25	o	I don't know.
1		No response
99 %		

EXERCISE 444

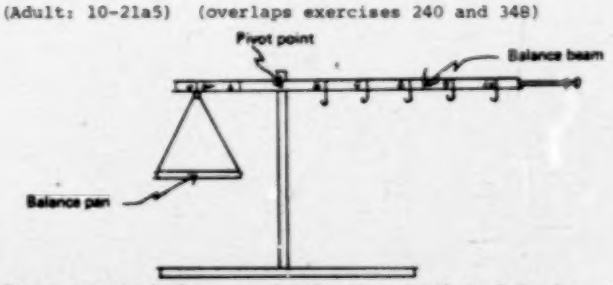
(Adult: 4-14) (overlaps Exercise 346)

A particular cell is shaped like a cube. If all its linear dimensions were doubled, its volume would increase

Adult		
4 %	o	3 times.
18	o	4 times.
9	o	6 times.
25	•	8 times.
16	o	16 times.
28	o	I don't know.
1		No response
101 %		

EXERCISE 445

(Adult: 10-21a5) (overlaps exercises 240 and 348)



The apparatus before you is the same as that shown in the picture. This balance is balanced when the balance beam is level as shown above. The number by each mark on the beam tells the number of inches that mark is from the pivot point.

(The apparatus also included 10-gram fishweights, a centimeter ruler, and a block of wood 10 x 3 x 2 centimeters. Respondents were given 20 minutes to answer several related questions (e.g., see Exercise 438). The following question was preceded by others which required them to make measurements which would assist them in answering it.)

5. What is the density of the wood block? It is _____ grams per cubic centimeter. (An answer between .38 and .64 was scored correct.)

Adult	
12 %	Correct
29	Incorrect
59	No response
100 %	

Objective III. Understand the Investigative Nature of Science

General Summary

Only two exercises are released for this objective. Both of them were answered correctly by a good many young adults.

446. A good many indicated understanding that measurement is not exact (57%).

447. A good many responded correctly that a theory can be described as, "a possible explanation for observations" (45%).

EXERCISE 446

(Adult: 6-17) (overlaps exercises 243 and 350)

Whenever scientists carefully measure any quantity many times, they expect that

Adult		
25 %	O	all of the measurements will be exactly the same.
1	O	only two of the measurements will be exactly the same.
2	O	all but one of the measurements will be exactly the same.
57	●	most of the measurements will be close but not exactly the same.
13	O	I don't know.
1		No response
99 %		

(overlaps exercises 243 and 350)

EXERCISE 447

(Adult: 10-13)

Which of the following is most likely to be called a theory?

Adult		
17 %	O	A fact based on experiments
3	O	A law of limited application
45	●	A possible explanation for observations
8	O	A conclusion reached from a single experiment
13	O	A series of experiments designed to test an observation
9	O	I don't know.
3		No response
98%		

Objective IV. Have Attitudes about and Appreciations of Scientists, Science, and the Consequences of Science that Stem from Adequate Understandings

General Summary

Only two exercises are released for this objective. The first of the two was answered in the direction consistent with the objective by most young adults.

448. Most Adults do not believe that United States scientists are ahead of scientists in other countries in every field of research (75%).

449. Only a few Adults state that if they learn about special television programs dealing with a scientific topic they would watch them often (29%).

EXERCISE 448

(Adult: 2-22) (overlaps Exercise 353)

United States scientists are ahead of scientists in other countries in every field of research.

Adult		
19 %	O	I believe this statement.
75	●	I don't believe this statement.
5	O	I don't know.
1		No response
100 %		

EXERCISE 449

(Adult: 10-1a) (overlaps Exercise 354)

(a) If you learn about a special television program dealing with a scientific topic, do you watch it?

Adult		
29 %	●	Often
56	O	Sometimes
15	O	Never
0		No response
100 %		

ILLUSTRATIONS OF ANALYSES IN PROGRESS (GROUP COMPARISONS)

The sort of descriptive information about educational attainments which National Assessment has gathered is new. This chapter is concerned with methods for describing results for groups within the population. The planning and supervision of the analysis has been the responsibility of the Analysis Advisory Committee (ANAC), a group of people experienced with statistics and measurement. They have been associated with National Assessment since it was begun in 1964,[4] and have been working with the staff of National Assessment on appropriate analyses and informative methods for presenting results.

This section of the report is aimed to illustrate some of the procedures that can be used for analyzing the data, and which will be used in a more complete report which will be forthcoming from the Science assessment. The results that appear are only for illustration.

Groups--and Subgroups

The analyses of the first National Assessment of 17-year-olds will examine certain major groups defined in terms of region, size and type of community, sex, color, and parents' education. (Appendix B defines these groups in more detail.)

1. four geographical regions--Northeast (NE), Southeast (SE), Central (Cent), and West (W).

2. four sizes of community (SOC)--Big Cities (over 200,000); Fringes around such cities; Medium-sized Cities (areas between 25,000 and 200,000 population) and the counties containing them; and Smaller Places (population less than 25,000).

[4] Members of ANAC are listed on the back of the title page.

3. four types of community (TOC)--Inner City, Suburb, Rural, and the Remainder of 17-year-olds. These TOCs were intended to permit consideration of three distinctive locales: the impoverished inner city, the affluent suburb, farms and smallest towns.

4. sex--Male and Female.

5. color--Black and non-Black.

6. parents' education, for the parent who went furthest in school--(1) eighth grade or less; (2) some high school but did not graduate; (3) graduated from high school; and (4) education beyond high school.

Results for geographical regions, sizes of community, and sex have been promised since the earliest days of National Assessment. Originally reporting by socio-economic status was expected to provide an assessment of the educational progress of the poorer segment of the population. As public sensitivity to the asking of certain questions and difficulty of defining "poverty" were recognized, it became clear that direct measures of poverty were out of the question.

As a result, it was decided to represent socio-educational status defined by the occupation and education of each 17-year-old's parents. So far, differences associated with parental education seem larger and more important than those associated with parental occupation. Accordingly, the mair socio-educational emphasis in reporting will be on the groups defined by parents' education. Some analyses by parents' occupation may appear in later reports.

While 17-year-olds almost always answered questions about parental education and occupation, this could hardly be expected at age 13 and 9. Alternative questions were used, and their use in analysis and presentation is still being explored.

This chapter reports percentages for correct responses only. Later reports may perhaps analyze frequencies of selected incorrect responses in a similar way.

While comparisons across basic categories such as type of community are of first importance, the analysis needs to go further. Subgroups can be defined by combinations of characteristics used to define groups. Being both in an Inner City and in the Central region defines such a subgroup, whose performance may or may not be distinctive. There is a need to ask such questions and report about the answers. There is also a need for care and selectivity, since a large number of such subgroups may be defined.

Very few people are prepared to look perceptively at all the many percentages that could be reported. The development of objective and effective techniques of selective presentation will be important--and far from trivial.

Subgroups defined by pairs of characteristics can be so small as to make it unwise to report percentages of success for them. Table 4-1 reports, for one exercise, the numbers of 17-year-olds in the groups and subgroups defined by parents' education and size of community. This table shows groups and subgroups of all sizes from large to very small. Reporting percentages for such subgroups as respondents in big cities whose parents completed no more than eighth grade is not likely to serve a useful purpose because the number is very small. The same is to be said of the "unknown" group. All that such percentages can do for most readers is cause confusion.

There is a gradation from what clearly ought to be reported in detail to what deserves no attention. A technique of reporting is needed that expresses the dependability of the result in relatively simple terms, but which manages to offer a reasonable number of gradations from quite firm conclusions, through various shades of limited reporting, to silence.

TABLE 4-1

SUBGROUP AND GROUP SIZES[a] IN A 2-WAY TABLE
FOR EXERCISE 307 (Age 17)

Parents' Education vs. Size of Community

	Size of Community				
Par. Educ.	Big City	Fringe	Medium City	Smaller Places	Total
8th or below	30	14	27	55	126
Some HS	68	58	63	108	297
HS Graduate	171	154	209	189	723
Beyond HS	181	273	244	183	881
Unknown[b]	11	17	9	10	47
Total	461	516	552	545	2074

[a] These figures show the actual numbers of in-school 17-year-olds who took this exercise and all other exercises in package 2 at age 17. The numbers are not exactly proportional to the actual sizes of the groups and subgroups in the population (See Appendix C for details of the sampling plan).

[b] Education of parents not reported by respondent; numbers shown because they contribute to the total.

If we find that a group of 17s performs more or less successfully than the average 17-year-old, how then are we to describe this difference in success? The numerical difference in percentage gives part of the answer, but there is an uncertainty about this value which must be kept in mind.

Expressing Uncertainty

We must turn to statistical techniques to learn how much trust one can reasonably place in each difference in percentages. Selection of individuals to be assessed necessarily brings in chance; if the whole assessment procedure were to be repeated, the percentage of correct response for any exercise and group would change somewhat. How much change is likely depends upon the number of respondents and upon the details of the sampling procedure.

Statisticians can indicate the likely numerical limits on such sampling variation by giving a number known as the "standard error." Conventional statistical practice is to pay serious attention to values that depart from zero--or from some other reference value--by at least twice their standard error and to be quite confident of the direction of differences that reach three times their standard error.

Our aim is to report observed percentages in such a way as to leave the reader duly cautioned--neither over-attentive to dubious effects nor over-cautious. To this end we have developed the convention set out in Table 4-2 and now to be discussed.

If the size of the observed difference between two percentages is less than 1.5 times its standard error, we do not place enough confidence in the difference to discuss even its direction. Such observed differences may well have arisen from sampling variation. There is a considerable chance that the observed direction is the reverse of what is actually true for the whole of the group.

TABLE 4-2

CONVENTION ADOPTED IN THIS REPORT FOR SPEAKING OF A SAMPLE DIFFERENCE

Size of Observed Difference Divided by Its Standard Error	Form of Statement When Observed Difference is x Percent*
less than 1.5	(no statement)
at least 1.5, less than 2	"may be"
at least 2, less than 3	"perhaps x%"
at least 3, less than 5	"roughly x%"
at least 5	"about x%"

* Preceding "higher," "lower," and the like.

EXAMPLES

Observed Difference Divided by Its Standard Error	Range in Which the True Difference Probably Lies	Statement
$\frac{5\% \text{ (higher)}}{5\%} = 1$	-5% to 15%	--
$\frac{5\% \text{ (higher)}}{3\%} = 1.67$	-1% to 11%	may be higher
$\frac{5\% \text{ (higher)}}{2\%} = 2.5$	1% to 9%	perhaps 5% higher
$\frac{5\% \text{ (higher)}}{1.25\%} = 4$	2.5% to 7.5%	roughly 5% higher
$\frac{5\% \text{ (higher)}}{.83\%} = 6$	3.3% to 6.7%	about 5% higher
$\frac{10\% \text{ (higher)}}{4\%} = 2.5$	2% to 18%	perhaps 10% higher
$\frac{30\% \text{ (higher)}}{5\%} = 6$	20% to 40%	about 30% higher

Consider the first example in the bottom half of Table 4-2, for instance. The observed difference is 5% and the standard error is 5%. As the ratio is 1, we make no statement about such a difference. An observed difference of 5% with a standard error of 5% is reasonably consistent with a true difference anywhere between -5% and 15%. (Twice the standard error = 10%; 5% $\pm$ 10% = 15% and -5%.) The proper conclusion is that no difference is established.

Such a result would be important to any reader who anticipated a clear difference between the groups. Sometimes the absence of a difference is as vitally important as Sherlock Holmes' noticing of the dog that <u>did not</u> bark in the night.

If the ratio of observed difference to standard error is at least 1.5 but less than 2, we place some confidence in it. This is reflected in such language as "may be lower" or "may be succeeding more often" or "may be higher." This statement does not imply any confidence in the size of the difference, but it does accept the direction of the difference as rather likely to be confirmed in further samples.

Somewhat more confidence in both the direction and the size of the difference is warranted if its ratio to its standard error is at least 2. We refer to a difference that is between two and three times its standard error as "perhaps x% higher" (or lower).

In the third example (bottom half of Table 4-2) the observed difference is again 5% but the standard error is 2%. The ratio of the size of the difference to the standard error is 2.5 and we say that the observed value is "perhaps 5% higher" than the overall group. The true value, very likely, lies between 1% and 9%. It is quite unlikely that the true difference is in the reverse direction.

If the ratio of the size of the observed difference to standard error is at least 3 but less than 5, we say "roughly x% higher" (or lower). Finally, if the ratio is 5 or more, we say "about x% higher" (or lower). Two other examples illustrate the convention further.

Table 4-3 gives differences and standard errors for the four Regions, for Exercise 307. We go on to illustrate the use of the standard error in interpreting the observed differences.

TABLE 4-3

REGIONAL DEPARTURES FROM THE PERFORMANCE OF ALL 17s
SCIENCE EXERCISE 307

	% Correct	Difference Between Group and All 17s	Standard Error of Difference
all 17s	69.2		
NE	75.0	5.8	2.39
SE	63.9	-5.3	2.54
Cent	68.3	-0.9	2.24
West	67.8	-1.4	2.23

Respondents in the Northeast apparently perform the best on this exercise, those in the Southeast worst. These deviations may be expressed arithmetically as differences between the particular regional group percentage and the national average performance of all 17s. The standard errors of the differences are used to decide whether the differences are sizeable enough to be trustworthy indications of the directions in which the groups differ from all 17s.

The Northeast percentage shown in Table 4-3 exceeds that for all 17s by 5.8%. The standard error of this difference is 2.39%. The ratio is 2.4; that is, between 2 and 3 times the standard error. Therefore, we regard the difference as reliable in direction, and say, "On this exercise, the Northeast group does perhaps 6% better than all 17s."

The technically experienced reader will recognize that the conventions adopted here are not those usually recommended by statisticians. We have adopted our admittedly simplified way of expressing results with the aim of making interpretations clearer to the general public.

Group Comparisons

To illustrate the ways in which the results can be examined and the problems that arise, several Science exercises at age 17 have been analyzed by major groups. Comprehensive group results will be presented in the next report on the 1969-1970 Science assessment. The exercises reported here are not intended to be representative of the whole set of exercises. Generalizations about relative performance of the various groups should not be attempted from these isolated exercises.

Table 4-4 indicates the percentages responding correctly to Exercise 307, both overall and for each of the major groups; these results will be discussed in some detail. The total number of respondents to the exercise and the number in each group are also given.

It is natural to ask regarding each group how much its success differs from all 17s. Such differences are shown in the third column of Table 4-4. The fourth column shows an estimated standard error for each difference. The fifth column shows the difference divided by its standard error. The sixth column offers summary statements using the convention of Table 4-2.

For a division of the population into just two groups--for example, Males vs. Females--it will often be of interest to focus on the difference between the two groups rather than on the departure of one group from all 17s. Either comparison conveys essentially the same information; each difference will be nearly the same multiple of its standard error. This similarity of ratio holds for any pair of groups that, together, make up the population.

When the two groups are nearly equal in size their differences from all 17s will be nearly equal in size (and opposite in sign). Thus in Exercise 307 (Table 4-4) Females appear to do 2.1% less well than all 17s and Males appear to do 2.0% better than all 17s.

When the two groups are unequal in size, the two differences from all 17s can be radically different. For example, in the case of the results in Table 4-4 for Blacks and non-Blacks, the departure of Blacks from all 17s is between 2 and 3 times its standard error, and the departure of non-Blacks from all 17s is between 2 and 3 times its standard error. But the differences are far from equal in size.

There is great national concern about the achievement of Blacks in U.S. society and its educational system. The differences between achievements of Blacks and non-Blacks vary considerably even among these few exercises. As seen in Table 4-8 there are exercises where 17-year-old Blacks perform below the national level, and there are also exercises where the observed difference is negligible.

If it is true that Blacks are at least equal to non-Blacks on some educational outcomes and lag behind in others, the full results of National Assessment will be of use in directing the improvement of educational programs. It would be premature to try to draw inferences about the nature of the exercises where certain groups excel.

There is considerable risk of faulty conclusions when a comparison of Black and non-Black is made, since the two groups differ with respect to many other variables, including distribution over type of community and parents' education. A fairer comparison would consider differences between Blacks and non-Blacks who were similar in other respects. The possibility of making such more subtle comparisons from National Assessment data is mentioned in a later section of this report.

By our convention the results in Table 4-4 will be summarized in this language:

TABLE 4-4

Results For Exercise 307*

	(1) Number in Group	(2) % Correct	(3) Difference: Group vs. All 17s	(4) Approximate Standard Error of Difference	(5) Difference Divided by its Standard Error	(6) Statement About the Difference
All 17s[a]	2166	69.2%				
Region						
Northeast	570	75.0%	5.8%	2.39%	2.43	perhaps 6% higher
Southeast	479	63.9	-5.3	2.54	-2.09	perhaps 5% lower
Central	521	68.3	-0.9	2.24	-.40	--
West	596	67.8	-1.4	2.23	-.63	--
SOC						
Big City	487	73.6%	4.4%	2.42%	1.82	may be higher
Fringe	527	72.6	3.4	2.11	1.61	may be higher
Medium City	573	66.9	-2.3	1.93	-1.19	--
Smaller Places	579	64.4	-4.8	2.82	-1.70	may be lower
TOC[b]						
Inner City	213	69.6%	-0.6%	4.44%	-.14	--
Suburb	230	68.0	-2.2	2.76	-.80	--
Rural	172	65.3	-4.9	6.55	-.75	--
Remainder	1459	71.3	1.1	0.88	1.25	--
Sex						
Male	1041	71.2%	2.0%	1.27%	1.57	may be higher
Female	1124	67.1	-2.1	1.07	-1.96	may be lower
Color						
Black	263	59.3%	-9.9%	3.58%	-2.77	perhaps 10% lower
Non-Black	1901	70.2	1.0	0.46	2.17	perhaps 1% higher
Parents' Education						
8th or below	159	65.6%	-3.6%	4.57%	-.79	--
Some High School	332	60.9	-8.3	3.40	-2.44	perhaps 8% lower
HS Graduate	743	71.4	2.2	1.88	1.17	--
Post High School	881	71.5	2.3	1.59	1.45	--

[a] Small numbers of cases could not be classified into a subgroup, so subgroups may not add up to all 17s.

[b] The TOC subgroups include in-school 17s only. The assignment of out-of-school 17s to TOC categories is not yet completed. Differences for TOC groups shown in Column 3 are difference of the group percent from 70.2% the percent correct for all in-school 17s.

* (17:2-3) Any galaxy contains many (stars).

Among all 17-year-olds, approximately 69% responded correctly to Exercise 307. Examining various groups of respondents we see that:

1. The NE does perhaps 6% better than all 17s and the SE does perhaps 5% less well. The Cent and W differences are close to zero.

2. Big City and Fringe respondents may be succeeding more often than all 17s, while respondents from Smaller Places may be succeeding less often.

3. Although the Rural percentage of success is, on its face, less than that for all 17s, its standard error is also large, and no statement is made.

4. Females may be doing less well than all 17s; equivalently, Males may be doing better.

5. Non-Blacks do perhaps 11% better than Blacks. (Blacks do perhaps 10% less well than all 17s, non-Blacks do perhaps 1% better. The difference between non-Blacks and all 17s is small, but the standard error is also small.)

6. Respondents who have a parent who attended but did not complete high school are perhaps 8% less successful than all 17s. No statement is made about the group whose parents had no more than eighth grade schooling. It is possible that their performance does equal that of all 17s, but it is also possible that they do worse than those whose parents had some high school. The present evidence is too scanty for either conclusion about this group.

Summary statements about Exercise 307 and nine other Science exercises administered at age 17 are given in Tables 4-5 to 4-9. The exercise numbers given are those used in the section on 17s in Chapter 3. Since the 10 exercises come from 8 packages, more than 15,000 17-year-olds have contributed to one or another of the differences on each page. The data on which the summary statements are based are presented in Appendix D.

TABLE 4-5

REGIONAL GROUPS
COMPARED WITH ALL 17s ON
10 SCIENCE EXERCISES[a]

Exercise Number	Northeast	Southeast	Central	West
307	perhaps 6% higher	perhaps 5% lower	--	--
319	--	--	--	--
324	perhaps 8% higher	roughly 10% lower	--	--
329	--	--	--	--
336	--	may be higher	perhaps 2% lower	--
340	--	may be lower	--	--
341	perhaps 9% higher	perhaps 11% lower	may be lower	may be higher
349	--	perhaps 4% lower	--	--
351	perhaps 8% higher	--	--	perhaps 5% lower
352	--	perhaps 6% lower	--	--

[a] Appendix D gives the data on which the next five tables are based.

TABLE 4-6

SIZE-OF-COMMUNITY GROUPS
COMPARED WITH ALL 17s ON
10 SCIENCE EXERCISES

Exercise Number	Big City	Fringe	Medium-sized City	Smaller Places
307	may be higher	may be higher	--	may be lower
319	--	--	--	--
324	--	may be higher	--	--
329	may be lower	may be higher	--	--
336	--	--	--	--
340	--	--	may be higher	may be lower
341	--	perhaps 7% higher	--	--
349	--	roughly 4% higher	--	perhaps 3% lower
351	--	--	--	--
352	--	--	--	--

TABLE 4-7

TYPE-OF-COMMUNITY GROUPS
COMPARED WITH ALL 17s[a] ON
10 SCIENCE EXERCISES

Exercise Number	Inner City	Suburb	Rural	Remainder
307	--	--	--	--
319	--	may be lower	--	--
324	--	perhaps 10% higher	roughly 14% lower	--
329	perhaps 10% lower	perhaps 12% higher	--	--
336	roughly 5% lower	--	--	--
340	--	about 10% higher	--	may be lower
341	--	--	--	--
349	may be lower	perhaps 4% higher	perhaps 6% lower	perhaps 1% higher
351	may be lower	may be higher	roughly 10% lower	--
352	--	--	--	--

[a] Results are for in-school 17s only. The classification of out-of-school 17s by type of community is not completed.

TABLE 4-8

SEX AND COLOR GROUPS
COMPARED WITH ALL 17s ON
10 SCIENCE EXERCISES

Exercise Number	Male	Female	Black	Non-Black
307	may be higher	may be lower	perhaps 10% lower	perhaps 1% higher
319	perhaps 4% lower	perhaps 4% higher	--	--
324	--	--	about 20% lower	about 2% higher
329	roughly 6% higher	roughly 5% lower	about 18% lower	roughly 2% higher
336	roughly 3% higher	roughly 2% lower	--	--
340	--	--	about 24% lower	roughly 2% higher
341	perhaps 6% higher	perhaps 6% lower	roughly 25% lower	roughly 3% higher
349	--	--	roughly 15% lower	roughly 2% higher
351	--	--	perhaps 6% lower	perhaps 1% higher
352	--	--	may be lower	may be higher

TABLE 4-9

GROUPS DEFINED BY PARENTS' EDUCATION
COMPARED WITH ALL 17s ON
10 SCIENCE EXERCISES

Exercise Number	8th Grade or Below	Some High School	High School Graduate	Beyond High School
307	--	perhaps 8% lower	--	--
319	--	--	--	--
324	--	roughly 12% lower	--	roughly 7% higher
329	may be lower	about 13% lower	may be lower	about 9% higher
336	roughly 3% lower	--	--	may be higher
340	may be lower	perhaps 7% lower	--	roughly 6% higher
341	--	perhaps 11% lower	--	may be higher
349	perhaps 11% lower	--	--	about 4% higher
351	--	about 14% lower	--	about 8% higher
352	perhaps 14% lower	roughly 10% lower	--	about 6% higher

When many more exercises are reported, this method of summarizing the results of several exercises will allow one to look for interpretable patterns. Although some consistencies appear in the table, no generalizations should be attempted until more exercises are analyzed and reported.

Comparison with a Value Other than Zero

In the column in Table 4-9 referring to children whose parents had no more than eighth grade education, quite different things are said about their performance on different exercises. On five exercises no difference is stated; on another, the difference reaches "perhaps 14% lower." Should we feel sure that these exercises are behaving differently?

Suppose that, for the entire group of 17s whose parents did not go beyond the eighth grade, the percentage difference is the same for each exercise. Because of sampling error we expect some observed differences to be larger and some to be smaller than the average value. In Table 4-10 we collect from Appendix D the observed percentage differences and their standard errors for all 10 Science exercises. When we make a thorough examination, we conclude that this variation is not worthy of attention.

In order to ask how similar the percentage differences in the population group may really be, we are led to compare each observed difference with -7.2% (the average of all 10 differences). These comparisons are given in column (3) of Table 4-10 and are combined with the standard errors from column (2) in order to obtain the statements in column (5). We find that only one difference deserves any statement.

When we come to look at this one difference carefully, we notice (from Appendix D) that Exercise 336 was answered correctly by only 6.2% of all 17s. Even if no one in the group of 17s whose parents had no more than an eighth grade education had answered correctly, they would have been only 6.2% worse than the average. Clearly it is impossible for this group to do 7.2% worse than all 17s. Although a statement can be made about this comparison as being

TABLE 4-10

DIFFERENCES COMPARED WITH THEIR AVERAGE: AN EXAMPLE

(Data for 17-year-olds Whose Parents Did Not Go beyond 8th Grade)

Exercise Number	(1) % Difference from all 17s	(2) Standard Error of Difference	(3) Difference Compared with -7.2%	(4) Column (3) Divided By Standard Error	(5) Statement about Difference from -7.2%
307	-3.6%	4.57%	up 3.6%	.79	--
319	-3.5	5.35	up 3.7	.69	--
324	-4.8	9.89	up 2.4	.24	--
329	-8.8	4.96	down 1.6	-.32	--
336	-3.4	1.03	up 3.8	3.69	roughly 4% up
340	-13.1	6.84	down 5.9	-.86	--
341	-7.3	8.24	down .1	-.01	--
349	-10.6	4.54	down 3.4	-.75	--
351	-3.0	4.94	up 4.2	.85	--
352	-13.7	5.17	down 6.5	-1.26	--

Average of Differences -7.2%

different from -7.2% it is not a statement that is relevant to our original question.

If we set aside the one anomalous exercise, there is insufficient evidence that, for any exercise, the disadvantage of this group varies from -7.2%. This group is quite small; when we deal with larger groups we can make more stringent comparisons of their behavior on different exercises. We have already commented that the Black--non-Black comparisons vary considerably from exercise to exercise. A calculation like that in Table 4-10 shows that the variability <u>within</u> the Black group is not due to chance.

Answering More Subtle Questions

This chapter illustrates how we can discuss the relatively simple comparison of the performance of one group with that of all persons of the same age. We want to ask also about subgroups--e.g., about those who live in affluent suburbs and who live in the Southeast. With two kinds of classification, more questions to answer, and more ways to approach the data, the problem becomes complex. We will not give numerical examples now, but we will indicate some possible lines of approach.

Someone might ask, "Are Southeastern affluent suburbs unusual?" He might mean to ask:

(1) How does the performance of 17-year-olds in Southeastern affluent suburbs compare with that of all 17-year-olds?

Or he might instead want to know:

(2) How do 17-year-olds in Southeastern affluent suburbs perform, considering the performance of all Southeasterners, all residents of affluent suburbs, and all 17-year-olds?

To answer the first kind of question we just proceed with groups, forming a simple difference of percentages. The percentage for the subgroup is thus set against the value for the whole age level. The second question is harder to answer, but procedures for such a complex comparison are available.

A wholly different sort of question asks whether differences associated with types of community, which are distributed disproportionately in the various regions, could together account for the differences found among regional groups. This requires us to match distributions with respect to type of community for the regional groups before finding and comparing the relevant percentages. This, too, can be done.

Methods are available even for investigating questions that go beyond simple matching. We might raise such a question, for example, because we believe that the only variable which can be used for matching measures but one aspect of the sort of difference that we wish to eliminate.

Examples of such analyses will appear in the next report on the first administration of Science.

APPENDIX A

DEVELOPMENT OF NATIONAL ASSESSMENT EXERCISES*

Before assessment exercises could be written, it was necessary to define the educational goals for each subject area included in the project. Ralph W. Tyler, Chairman of the Exploratory Committee, and still actively associated with the project, explains:**

> A first major purpose for obtaining a list of educational objectives is to guide the development of the assessment instruments. The assessment should indicate the extent to which our people have attained important educational goals, i.e., have they learned what schools are expected to teach? Learning is a process of acquiring ways of thinking, feeling and acting, that is, acquiring patterns of behavior. A course outline commonly lists the content the course deals with, but it does not indicate what the student is to learn to do with this content. Is he to memorize it, recognize the principles involved and seek to use these principles in solving problems, to develop a skill in reading and analyzing the material or to develop a life-long interest in the subject, or some combination of these and other kinds of behavior? We need to know what the student is expected to learn in order to assess his achievement. For this reason, educators are writing objectives in terms of the behavior they expect to help students learn. Objectives written in these terms are necessary to guide the production of assessment exercises. Hence, objectives for the National Assessment were written in behavioral terms.

* For more information, see Finley, Carmen J. and Berdie, Frances S. The national assessment approach to exercise development. Ann Arbor, Michigan: National Assessment of Educational Progress, 1970.

** Tyler, Ralph W. Personal letter to Carmen J. Finley, February 1, 1970.

The educational objectives for all 10 subject areas were developed with the intention that they must be:

1. considered authentic by scholars in the area.
2. accepted as an educational task by schools.
3. regarded as desirable by thoughtful lay citizens.

Several hundred people of each type joined to develop or review objectives. The Science objectives, and subsequently, the Science exercises, were put into final form by the Educational Testing Service under contract with National Assessment.

Subject matter experts, other educators, and lay people, thus defined four major objectives for Science:

I. Know fundamental facts and principles of Science.

II. Possess the abilities and skills needed to engage in the processes of Science.

III. Understand the investigative nature of Science.

IV. Have attitudes about and appreciations of scientists, science, and the consequences of science that stem from adequate understandings.

These were amplified by statements which explained in detail what each major objective included. Illustrations of types of behavior which could indicate whether the objective and subobjective were being attained were also appended.*

For example, a subobjective under Objective II states that individuals should have the ability to identify and define a scientific problem. At age 9, children should be able to recognize problems in simple, familiar situations. At age 13, children should also be able to recognize problems in unfamiliar situations. The 17-year-olds should be able to define the problem reasonably well in terms which would

*

The complete statements of objectives and subobjectives are given in:

Norris, Eleanor L. (Ed.) Science objectives. Ann Arbor, Michigan: Committee on Assessing the Progress of Education, 1969.

allow investigation. Adults should be able to recognize problems in situations which are related to their own recent experiences, rather than in situations that are "bookish."

Once objectives were stated, writing of exercises began. Exercise writers were told to develop exercises:

1. that sample some important knowledge, skill, or attitude,

2. in whatever form or mode seemed most appropriate to the assessment of a particular objective, and

3. that call for knowledge and skills of varying difficulty, some which almost everyone has acquired, some which only about half have acquired, and some which only the most able are expected to do.

The first requirement--to sample knowledge, skill, or attitude, needs little explanation. The second, that exercise writers should choose any suitable format, perhaps is an unusual requirement. The intent was to encourage writers to use the best format for the type of knowledge or skill being assessed. To see whether a certain task can be performed, for example, an exercise could ask the respondent to perform the task rather than ask him whether he can do it, or to describe how he would do it. On the other hand, to learn whether the respondent knows a particular fact, a simple multiple-choice exercise may be most appropriate. Most Science exercises are multiple-choice, but there are several performance exercises which require the respondent to manipulate an apparatus to answer certain questions and a few short answer exercises.

To describe the National Assessment policy on spread in difficulty we can again quote from Dr. Tyler:

> The traditional achievement test is constructed to measure individual differences and to furnish reliable average scores for grades or schools. The test items, therefore, are concentrated on those which are typical of average performance. Exercises which all children or nearly all children can do, as well as those which

> only a very few can do, are eliminated from such tests. In reviewing current tests to see whether they could be used in the National Assessment, we found that more than 80 percent of the items in the most widely used achievement tests would be answered correctly by 40 percent to 60 percent of those who took them. Only about five percent of the items were exercises which could be answered by students in the lower third of the class, and another five percent represented tasks appropriate for the upper third. For assessing the progress of education, and for informing teachers, principals, and parents in local schools about the achievements of their children, we need to know what <u>all</u> children are learning--the disadvantaged or "slow" learners, the most advanced, and the middle or "average." The construction of exercises appropriate for these purposes has been a challenge....*

A number of other policies were established, including:

1. Exercises must have content validity. Simply stated, this means that an exercise must clearly belong to the area of knowledge, skill, or attitude with which it is identified.

2. Exercises must be written so that it is possible to distinguish acceptable from unacceptable responses.

3. Exercises must be stated so that the respondent understands what is being asked of him. In Dr. Tyler's words: "It is <u>extremely</u> important to distinguish between failure on an exercise <u>because the child doesn't understand what he is asked to do</u> and failure <u>because he is unable to do the task</u>."**

* Tyler, Ralph W. National Assessment-some valuable by-products for schools. In <u>The National Elementary Principal</u>, May, 1969, 48: 6, 45.

** Ibid.

Exercise writers generated a large pool of exercises, not all of which could be used. Many were inconsistent with some one of the National Assessment policies. The adequacy of those retained for use was checked by having exercises reviewed for soundness by subject matter experts and by lay people for pertinence and absence of offensiveness.

The number of accepted exercises was too large for all to be administered. Frank B. Womer, NAEP Staff Director, discusses this point:

> Time available for administration became the crucial variable in setting the upper limits for the number of exercises to be used during the first year of assessment. On the average about 160 minutes of assessment time were available for each subject area for each age. This was dictated by monies available for the actual field administration work. This meant that for each age group selected, all of Science had to be sampled in about 160 minutes, all of Writing in about 160 minutes, and all of Citizenship in about 160 minutes. When multiple-choice exercises were used primarily, as in Science, quite a few could be asked in 160 minutes.*

This reference to the 160 minutes in which to assess Science might lead one to think that each respondent had to spend 160 minutes on each of three subject areas--480 minutes in all--to complete his contribution to the project. In order to avoid such a demand for time, exercises were divided so that any one respondent gave only 40 to 50 minutes. In that time he could receive directions and complete the booklet, or package, of exercises assigned to him. For example, one package of exercises used in 1969 contained 11 exercises. Of these, seven were Science exercises, three were Citizenship exercises, and one was a Writing exercise. The purpose of National Assessment is to report the proportion of people able to answer certain exercises successfully, not to score each individual who participates. Administering exercises in packages provides the necessary information without overburdening the individual respondents.

* Womer, Frank B. What is National Assessment? Ann Arbor, Michigan: National Assessment of Educational Progress; P. 20-21.

APPENDIX B

Definition of Terms

The major reporting categories used in this report are: Age, Region, Size of Community (SOC), Type of Community (TOC), Sex, Color, and Parents' Education.

1. Age: Four age levels were assessed. Three of these were in-school--9, 13, and 17-year-olds; and two--17s and young adults--were out-of-school, sometimes referred to as the household sample. The criteria used or the operational definitions of the four ages are as follows:

   9s--Born between 1/1/60 and 12/31/60
   13s--Born between 1/1/56 and 12/31/56
   17s--In-school: Born between 10/1/51 and 9/30/52
   Out-of-school: Born between 10/1/50 and 9/30/51 and <u>not</u> enrolled in school in March '68 OR born between 10/1/51 and 9/30/52 and <u>not</u> enrolled in school in March 1969.
   young adults--Born between 7/1/33 and 6/30/43

2. Region: Four geographical regions are being used for <u>all</u> age levels--<u>Northeast</u>, <u>Southeast</u>, <u>Central</u>, and <u>West</u>. The states falling in each of these four regions, for reporting purposes, are as follows.

Northeast	Southeast	Central	West
Del.	Ala.	N.D.	Hawaii
Maine	Ark.	S.D.	Alaska
N.H.	Fla.	Iowa	Idaho
Vt.	Ga.	Kansas	Mont.
D.C.	Ky.	Minn.	Wyo.
Md.	La.	Mo.	Utah
N.J.	Miss.	Neb.	N.M.
N.Y.	N.C.	Ill.	Nev.
Conn.	S.C.	Ind.	Cal.
Pa.	Tenn.	Mich.	Ore.
Mass.	Va.	Ohio	Wash.
R.I.	W. Va.	Wis.	Ariz.
			Colo.
			Tex.
			Okla.

This classification is that used by the Office of Business Economics, Department of Commerce; the names for regions used by OBE differ from National Assessment names for three regions:

National Assessment	OBE
Northeast	Northern Atlantic
(Southeast)	(Southeast)
Central	Great Lakes and Plains
West	West and Northwest

3. Size of Community (SOC): The four reporting categories for SOC were (1) Big Cities, (2) Fringes around Big Cities, (3) Medium-Sized Cities, and (4) Smaller Places. They were defined as follows:

SOC Category	Description
Big Cities	All central cities of the U.S. with a population of 200,000 or greater.
Fringes around Big Cities	For each county containing a city in the Big City SOC category, the region of the county not within the city limits plus all counties within the same Standard Metropolitan Statistical Area (SMSA) as the "Big City".
Medium-Sized Cities	All SMSA counties not included in Big Cities or Fringes SOC categories plus all counties which contain at least one city of 25,000 people or more. If such a city was a part of more than one county, the county with a majority of the city population was classified here.
Smaller Places	All counties and combinations of counties with a population under 25,000 not included in the above categories.

4. Type of Community (TOC): Exploratory analysis of a substantial number of exercises for a classification into about 7 kinds of community indicated rough gradations of performance, differing from exercise to exercise, with the extreme behavior shown by two or more of (1) small places, (2) large cities, (3) suburbs. The size of community classification which was used in designing and implementing the sample, revealed this behavior, but only to a limited degree. The Type of Community (TOC) classification was developed to show more clearly how large the extreme differences in performance are.

   By classifying schools rather than counties, it was possible to identify much more uniform groups. One extreme group was selected in each of the three directions indicated by the exploratory analysis: (1) schools where high proportions of parents were farm workers and only low proportions were factory or professional workers, (2) city schools where a high proportion of parents were either not regularly employed or on welfare, and only a low proportion were professional or managerial, (3) near-city and city schools where a high proportion of parents were professional or managerial and only low proportions were factory or farm workers, not regularly employed or on relief.

   Smaller extreme groups would have been more extreme; larger extreme groups would have had better determined percentages of success. The sizes of the three extreme groups, close to 10% of all those assessed, were chosen as a compromise between more extremeness and better determination.

   (Since only schools at which assessments were made were classified, no one can draw a map showing which areas of the U.S. belong to each Type of Community group. Where such a possibility is important, the TOC grouping is inferior to the SOC grouping. To give a good idea of broad extremes, on the other hand, the TOC grouping is much more revealing than the SOC grouping.)

   The four classifications are referred to as:

1. Impoverished Inner-City
2. Affluent Suburb
3. Farm and small town
4. Remainder

The "extremes" were identified by NAEP staff using responses from questions 2 (size) and 3 (occupational level) of a questionnaire filled out by each high school principal. Questions 2 and 3 of the questionnaire are reproduced below.

Q. 2. Approximately what percentage of the students attending your school live in each of the following areas?

_____% A In a rural area (Less than 2,500)
_____% B In a town of 2,500 to 10,000
_____% C In a town of 10,000 to 25,000
_____% D In a city of 25,000 to 200,000
_____% E In the suburbs of a city of 25,000 to 200,000
_____% F In the inner part of a city over 200,000
_____% G In the residential area within the city limits of a city over 200,000
_____% H Outside the city limits of a city over 200,000 but within the residential area served by the city

100% (This column should add to 100%)

Q. 3. Approximately what percentage of the students attending your building are children of

_____% A Professional or managerial personnel
_____% B Sales, clerical, technical or skilled workers
_____% C Factory or other blue collar workers
_____% D Farm workers
_____% E Not regularly employed
_____% F On welfare

100% (This column should add to 100%)

Computation of "Extremes"

Impoverished Inner-City: All schools located in the inner part of a city over 200,000 OR in the residential area within the city limits of a city over 200,000 OR outside the city limits of a city over 200,000 but within the residential area served by the city were identified. (F,G,H, in Q.2) The following index was computed on the basis of responses to Q.3.

$$I_{Ic} = (E+F) - A$$

These values were then used to classify the "extreme" Impoverished Inner-City schools.*

Affluent Suburb: All schools classified as being in the inner part of a city over 200,000 OR in the residential area within the city limits of a city over 200,000 OR outside the city limits of a city over 200,000 but within the residential area served by the city were identified. (F,G,H, in Q.2.) Then on the basis of the principal's responses to Q.3., the following index was computed:

$$I_S = A - (C+D+E+F)$$

These values were then used to classify the "extreme" Affluent Suburb schools.

* The "cut-off values" for each TOC group are given in the table on B-6.

Farm and Small Towns: All schools classified as being in a rural area (less than 2,500) OR in a town (2,500-10,000) were identified. (A+B in Q.2.) Then on the basis of responses to Q.3. the following index was computed

$$I_R = D - (C+2A)$$

The values of these indices were used to determine those schools classified as coming from Farm and Small Towns.

Remainder: All schools not classified as Farm and Small Towns, Impoverished Inner-City, or Affluent Suburb.

Note 1: There were a few instances where there was either a misclassification made by the principal, OR there was missing data, OR there was a paucity of schools selected using the index computed by the formulas described above. When this was the case, NAEP staff used their field personnel, atlases, maps, etc., to classify schools.

Note 2: In some earlier material issued by National Assessment the words "Type of Community" were used for what is here called "Size of Community."

Cut-Off Values of Indices for Defining TOC

TOC Sub-Population	In-School Samples 9-year-olds	13-year-olds	17-year-olds[1]
	Cut-off[2] value of Index		
Inpoverished Inner-City	.16	.17	-.07
Affluent Suburb	0	-.30	.08
Farm and Small Places	-.20	-.20	-.10

[1] The constraint with respect to Question 2 was not applied as rigorously at age 17 as at the other 2 ages.

[2] Schools that had an index value greater than or equal to its cut-off value were included in the stated TOC category.

5. Sex: Data are reported for Males and Females

6. Color: Data are reported for Blacks and non-Blacks. Color classification was based on observation of the respondent at the time of the administration by the field staff member who administered the package.

7. Parents' Education: All data are reported in terms of the highest level of education of either parent or guardian of a 17-year-old respondent. Parents' Education is reported as follows:

    Level 1. Less than or equal to 8th grade
    Level 2. More than 8th grade but not a high school graduate
    Level 3. Graduated from high school
    Level 4. Some formal education beyond high school

Appendix C

STRUCTURE OF SAMPLING AND WEIGHTING*

I. Introduction

The sample for the National Assessment of Educational Progress was designed with several general objectives in mind.

(1) To represent adequately certain subpopulations specified by NAEP, including the oversampling of some of these subpopulations to obtain a more nearly balanced sample.

(2) To allow the administration of several packages of exercises with each package comprising a single survey in the usual sample design sense.

(3) To obtain precise estimates at the lowest possible cost.

(4) To allow for subsequent manipulation of the data by NAEP or its advisory committees to obtain subpopulation specific estimates on a post-definitional basis.

(5) To facilitate smooth field operating procedures and control the workload at any single sample point.

(6) To the extent possible within the above objectives, to provide for relatively simple estimation procedures.

As a result of considering these several objectives, the sample design has evolved into a stratified multi-stage design. However, most of the stages are due to the methods of administration of the packages and the oversampling of low socio-economic status (SES) 17-year-old students within schools.

Since there are several packages, several exercises per package, and several possible responses per exercise, the number of estimates which may be called for from each subpopulation is large. As an example, for seventeen-year-olds, 14 different packages were used. If each package contains an average of 15 exercises with 5 multiple choices per exercise (or equivalently, has a 5-point reporting scale), then 1050 (14 x 15 x 5) separate estimates could be computed for each subpopulation. The estimate, $\hat{P}$, will pertain to a specific exercise and a specific scale-point or category for that exercise; e.g., consider the subpopulation of all 17-year-old males in the United States and an exercise that requires a "yes" or "no" answer.

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* Prepared by J. R. Chromy and D. G. Horvitz, Research Triangle Institute.

A population parameter, P_1 , is defined as follows

$$P_1 = \frac{Y}{X} \tag{1}$$

where X , the denominator, is the total number of 17-year-old males in the United States, and Y , the numerator, is the number of such males that would answer "yes" to the exercise. Similar parameters could also be defined for those answering "no," P_2 , and for those answering "I don't know," P_3 . Note that

$$P_1 + P_2 + P_3 = 1 , \tag{2}$$

provided each 17-year-old male would give one of the three answers.

Each of these parameters, say P_i , is estimated by first estimating the numerator, Y , and denominator, X , and then expressing the estimate, $\hat{P}$, as

$$\hat{P} = \frac{\hat{Y}}{\hat{X}} \tag{3}$$

where $\hat{X}$ and $\hat{Y}$ are the estimates of X and Y , respectively. Such an estimate is called a "combined ratio estimate" when it is applied to a stratified sample. The sample design and the estimation procedures described here provide for unbiased estimates $\hat{X}$ and $\hat{Y}$ of X and Y.

The following sections describe the sample design and associated estimation procedures at each stage.

II. First-Stage Sample Design and Estimation Procedures

A. Frame

Listing units are small geographic areas with readily identifiable boundaries. For National Assessment listing units usually consist of a county; in some cases, listing units are made up of several counties in order to meet the minimum size requirement (16,000 persons). Other listing units are parts of counties. Large central cities could thus be sampled independently of surrounding areas falling within the same county.

For National Assessment the first stage or primary sampling units PSUs are portions of listing units, containing approximately 16,000 persons as of the 1960 census of population. A listing unit always contains at least one primary sampling unit; some listing units contain several; e.g. the city of San Francisco is a listing unit and contains 45 primary sampling units as defined above.

Every square foot of land area in the 50 states and the District of Columbia was assigned to some listing unit. The number of primary sampling units in each listing unit was determined or assigned on the basis of the population of the listing unit. The detailed array of these listing units is called the sampling frame. This type of sampling frame is sometimes referred to as an area sampling frame.

B. Sample Size and Allocation

One of the sample design decisions was to fix the second-stage sample size per primary sampling unit. This course was taken to satisfy objective (5) in Section I above. It was decided that a sample size of 2,000 responses per exercise would provide sufficiently precise estimates at the national and regional levels. A somewhat larger sample size (about 2500 responses per exercise) was considered necessary for exercises administered in group sessions because of the higher intraclass correlation effect. Optimum cluster size was determined on the basis of minimum variance for a fixed cost assuming carefully chosen approximate cost and variance functions. These factors entered into the decision to use a sample size of 208 PSUs with 10 to 12 observations per package in each PSU.

The 208 PSUs were allocated equally to the four major regions of the U. S. with 52 being assigned to each. The next major partition of the listing units within regions was by size of community categories or strata. PSUs were allocated to the size of community strata on a proportional-to-population basis within each region. The sample PSU allocation is shown in Table 1.

Table 1

Sample PSU Allocation by Region and Size of Community

Region	Size of Community Category * 1	2	3	4	Regional Totals
Northeast	15	15	15	7	52
Southeast	8	6	15	23	52
Central	12	12	12	16	52
West	15	14	12	11	52
U. S.	50	47	54	57	208

* The four columns of the Size of Community Category (S.O.C.) represent: (1) central cities with a 1960 population of 180,000 or greater; (2) metropolitan areas around these (S.O.C. 1) cities; (3) other metropolitan areas and other counties containing a city with 15,000 or more persons in 1960; and (4) all remaining areas.

C. Stratification

Each listing unit corresponds to some identifiable land area which has associated characteristics. These characteristics were used as stratification variables.[1/] As mentioned earlier, each listing unit fits uniquely into one region and one size of community category. Further stratification (labelled "serial") of the listing units was based on a combination of a listing unit income variable (percent of families earning less than $3,000) and geographic location within region. No attempt was made to guarantee that each state have at least one sampling unit.

Table 2 shows the SNPs (sample number prefixes) that result from the allocation of the sample to region, size of community, and location (listing unit-income groups). Allocation of the samples to the SNPs had to be disproportionate and involved some deliberate oversampling of the SNPs with low listing unit incomes, but proportionate allocation was used within SNPs.

In general, two PSUs were selected from each stratum in order to maximize the gains from stratification and yet retain the ability to compute estimates of sampling errors from the survey data without further assumptions. Whenever an odd number of PSUs was selected from some larger subset of the sampling frame, one of these PSUs was selected from a "half-stratum." Table 2 also provides data on the number of PSUs and strata for each SNP.

D. Specification of Primary Sampling Units Within Listing Units

It has been stated that each listing unit contains at least one primary sampling unit (PSU) and that the sampling frame consists of listing units which completely exhaust all the land area in the United States. The method of sample selection used was to draw one or two PSUs per stratum with equal probability and without replacement.

At first examination, it appears that the sampling frame for such a selection method should have been a list of primary sampling units. However, construction of such a list would have required extensive partitioning work within each listing unit containing more than one PSU regardless of whether that listing unit fell into the sample or not. Much unnecessary work was avoided by simply developing a rule which specified the labels or serial numbers of the PSUs within each listing unit; the rule used was simply to keep a running accumulation of the number of PSUs in the list of listing units. Table 3 illustrates this procedure. Random

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1/ The data source for characteristics of listing units was the County and City Data Book, 1967. Certain parts of the data for each county and large city were obtained from the Bureau of the Census on punched cards.

Table 2

Primary Sampling Units by SNP

Sample Number Prefix (SNP)			Total Number of PSUs	Number of PSUs in Sample	Number of Strata
Region*	S.O.C.**	Serial	N	n	***
1	1	1	275	5	2†
1	1	2	38	2	1
1	1	3	124	4	2
1	1	4	77	2	1
1	1	5	33	1	†
1	1	6	41	1	†
1	2	1	870	15	7†
1	3	1	155	5	2†
1	3	2	645	10	5
1	4	1	57	2	1
1	4	2	275	5	2
			(2590)	(52)	
2	1	1	361	8	4
2	2	1	288	6	3
2	3	1	120	5	2†
2	3	2	545	10	5
2	4	1	161	7	3†
2	4	2	760	16	8
			(2235)	(52)	
3	1	1	564	8	4
3	1	2	43	2	1
3	1	3	66	2	1
3	2	1	738	12	6
3	3	1	140	4	2
3	3	2	616	8	4
3	4	1	150	5	2†
3	4	1	682	11	5†
			(2999)	(52)	
4	1	1	451	11	5†
4	1	2	42	3	1†
4	1	3	32	1	†
4	2	1	360	9	4†
4	2	2	205	5	2†
4	3	1	66	3	1†
4	3	2	450	9	4†
4	4	1	60	3	1†
4	4	2	288	8	4
			(1954)	(52)	
			(9778)	(208)	

* The first digit of the sample number designates the region as: (1) Northeast; (2) Southeast; (3) Central; or (4) West.

** The second digit of the sample number designates the size of community (S.O.C.) stratum as: (1) central cities with a 1960 population of 180,000 or greater; (2) metropolitan areas around these (S.O.C. 1) cities; (3) other metropolitan areas and other counties containing a city with 15,000 or more persons in 1960; and (4) all remaining areas.

*** The symbol "†" indicates a "half-stratum."

Table 3

Illustration of Primary Sample Selection Procedure

Listing Unit Name (A)	1960 Population (B)	Number of Primary Sampling Units Assigned: To Listing Unit (C)	Number of Primary Sampling Units Assigned: Accumulated (D)	Labels Assigned to PSU s in Listing Unit (E)	Random Numbers Selected (F)
Bergen, N. J.	780,254	48	48	1 to 48	24
Middlesex, N. J.	433,856	27	75	49 to 75	
Broome, N. Y.	212,661	13	88	76 to 88	79
New Castle, Del.	307,446	19	107	89 to 107	
Mercer, N. J.	266,392	16	123	108 to 123	

selections of one or two labels were made from random number tables.[2] It was then possible to identify the listing units involved in the sample, since these were the ones containing the selected labels. It was not necessary to partition or construct PSU s within any other listing units. In the example given in Table 3, the listing units of Bergen County, New Jersey and Broome County, New York were selected by the random numbers 24 and 79, since the corresponding labels are included in those assigned to the PSU s for these listing units.

Within selected listing units, PSU s were constructed in one-to-one correspondence with the labels assigned to the listing unit. Since the label selected was known, the assignment of the labels to the PSU s was accomplished in an unbiased fashion by using a table of random permutations.[3]

This method of selecting and forming PSU s is particularly adaptable to National Assessment, since four different age-defined target populations must be sampled: 9-year-olds, 13-year-olds, 17-year-olds, and young adults between the ages of 26 and 35. For the young adult sample, the primary sampling unit can be defined as an area unit just as the listing unit has been defined as an area unit, since this target population will be sampled by means of a household survey. The same principle holds for 17-year-olds who have completed or dropped out of high school. Nine-year-olds, 13-year-olds, and in-school 17-year-olds are sampled through their schools. Therefore, a list frame of schools within each selected listing unit must be used to construct the primary sampling units for these student populations; the PSU s for the different age groups will not normally coincide since the enrollment of students of a particular age depends upon the grade range taught at each school.

A general rule followed in the formation of PSU s within listing units was to form heterogeneous clusters with particular emphasis placed on representing some of both the high and the low socio-economic status populations within the listing unit.

E. The Out-of-School Sample

As indicated above, the same basic primary sample design applies to both the in-school and out-of-school (household) samples. The difference between the two primary samples is that the PSU in the school sample is defined in terms of persons enrolled in school and belonging to certain age groups while the PSU in the household sample is defined in terms of the household population belonging to certain age groups.

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[2] The RAND Corporation, A Million Random Digits.

[3] Moses and Oakford, Tables of Random Permutations.

The target populations for the household sample are:

(1) Adults 26-35.

(2) Out-of-school seventeen-year-olds.

In both the in-school and out-of-school samples, the primary sample consisted of a stratified random sample of 208 PSU s. The same random draw was used to select PSU s in both samples; however, the ultimate definition of each PSU was achieved by different methods because of different definitions of the target populations.

F. Estimation Procedures at the First Stage

Consider again the estimation of some population parameter, P, which refers to a particular target population and a particular category of response on a single exercise. The following parameters are defined for the i-th PSU within the h-th stratum:

X_{hi} = the number of persons in the target population in the i-th PSU of the h-th stratum, and

Y_{hi} = the number of such persons that choose a particular response category to the exercise.

These parameters are related to X and Y in Section I (Introduction) by the relations

$$X = \sum_{h=1}^{L} \sum_{i=1}^{N_h} X_{hi} \text{ , and} \tag{4}$$

$$Y = \sum_{h=1}^{L} \sum_{i=1}^{N_h} Y_{hi} \tag{5}$$

where N_h is the number of PSU s within the h-th stratum and L is the total number of strata.

If X_{hi} and Y_{hi} were determined for each PSU selected in the sample, the population parameters X and Y would be estimated by $\hat{X}$ and $\hat{Y}$, respectively as:

$$\hat{X} = \sum_{h=1}^{L} \frac{N_h}{n_h} \sum_{i=1}^{n_h} X_{hi} \text{ , and} \tag{6}$$

$$\hat{Y} = \sum_{h=1}^{L} \frac{N_h}{n_h} \cdot \sum_{i=1}^{n_h} Y_{hi} , \qquad (7)$$

where n_h is the PSU sample size for the h-th stratum.

Since not all eligible persons in a PSU are included in the sample, and since, for the most part, each person in the sample responds to only one package, the parameters X_{hi} and Y_{hi} will not be determined exactly. Instead, these parameters have to be estimated on the basis of data collected from a small subsample of the total PSU. The subsampling procedures and related within-PSU estimation procedures are discussed in Section III. If the estimates of X_{hi} and Y_{hi} are denoted by $\hat{X}_{hi}$ and $\hat{Y}_{hi}$, respectively, formulas (6) and (7) can be restated in terms of the PSU estimates as

$$\hat{X} = \sum_{h=1}^{L} \frac{N_h}{n_h} \sum_{i=1}^{n_h} \hat{X}_{hi} , \text{ and} \qquad (8)$$

$$\hat{Y} = \sum_{h=1}^{L} \frac{N_h}{n_h} \sum_{i=1}^{n_h} \hat{Y}_{hi} . \qquad (9)$$

The combined ratio estimate of P can then be written as

$$\hat{P} = \frac{\hat{Y}}{\hat{X}} = \frac{\sum_{h=1}^{L} \frac{N_h}{n_h} \sum_{i=1}^{n_h} \hat{Y}_{hi}}{\sum_{h=1}^{L} \frac{N_h}{n_h} \sum_{i=1}^{n} \hat{X}_{hi}} \qquad (10)$$

G. Sub-Population or Domain Estimates

It should be noted that formula (9) above is equally applicable to an aggregate population estimate or to any subpopulation estimate as long as the $\hat{Y}_{hi}$ and $\hat{X}_{hi}$ are defined with respect to the subpopulation or domain of interest. The subpopulations may be defined in advance of sampling or in an after-the-fact manner. Usually the sample size for a

specific subpopulation will itself be a random variable. Hartley presents the theory of mean and variance estimation and gives appropriate formulas under several sample designs.4/

The parameters, X_{hi} and Y_{hi}, may both be equal to zero for several PSU s if these PSU s do not contain any members of the subpopulation of interest. The sample estimates, $\hat{X}_{hi}$ and $\hat{Y}_{hi}$, may be equal to zero for this same reason, and they may also be equal to zero in some PSU s due to sampling even when the associated parameters X_{hi} and Y_{hi} are not equal to zero. Some restraint must be exercised in defining subpopulations of interest to insure that at least some of the $\hat{X}_{hi}$ are non-zero. An examination of the sample size and variance with respect to each subpopulation estimate will provide guidance for defining subpopulations after the fact for which appreciably precise estimates are possible.

4/ Hartley, H. O. (1959), "Analytic studies of survey data," Instituto di Statistica, Rome, volume in honor of Corrado Gini.

III. Second-Stage Sample Design and Estimation Procedures

A. The Sampling Problem Within the PSU

The requirements placed on the sample design within each PSU for the National Assessment of Education differ in several ways from those usually considered in designing a multi-stage survey. The most distinctive features involve the use of several packages combined with the requirement that a probability subsample be used for each package. This amounts to simultaneously designing samples for several separate surveys and constructing estimates for each of these surveys. Moreover, in the school sample, administration modes of the packages differ. The within-PSU sample design for packages administered to group sessions differs from the sample design for packages administered individually.

B. The In-School Sample

1. The sample design

An additional constraint on construction of PSU s was that at least two schools should be involved in the sample within each PSU. Generally, PSU s within listing units have been formed so as to constitute a heterogeneous sample of the listing unit. The number of schools associated with each PSU was minimized subject to the above constraint and the requirements that all elementary and secondary schools (public and private) be included in the sampling frame as part of some PSU for each age-specific target population.5/

Although the actual size of PSU in terms of number of students of a specific age group will vary from PSU to PSU and can only be determined after the fact, a target PSU size of 250 to 350 students in each age group was expected in each PSU based on the general population data used in constructing the sampling frames. Random subsamples of the 250 to 350 students in each of the three age groups actually participated in National Assessment. Since the PSU size is limited and each PSU must involve at least two schools for each age group, some large schools contribute to several PSU s. As an example, a school with 900 17-year-old students might contribute 150 students to the construction of each of 6 different PSU s. The definition of a particular PSU involves a list of schools. For each school listed, a special factor, S , is computed which indicates the proportion of that school belonging to the PSU. An example of such a listing is shown in Figure 1. The school factor, S , for each school is shown in column 10 of Figure 1.

5/ Schools listed as teaching a grade span with an upper limit no higher than the eighth grade were assumed to contain no 17-year-old students.

SAMPLE SCHOOLS SELECTED

Sample Number 111011
State State Name
County(ies): County Name
Number of SU s Assigned to LU 10
Average Number of Approximated 17-Year-Olds per 1/2 SU 145

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
School Code	Zip Code	School Name	School Address	School Principal	Grades Taught	Est. # 17 s in School	# of 1/2 SU's Assigned to School	# of 1/2 SU's Assigned to SU	Ratio of Col. (9) to Col. (8)	Poverty Index
1	90002	Public No. 21	----------	---------	K-12	870	6	1	.17	H
2	91105	Private School 1	----------	---------	9-12	145	1	1	1.00	L
3	84821	Public No. 5	----------	---------	K-8	0	--	--	1.00	M

FIGURE 1. An Example of a PSU School List

Whenever school personnel in the 17-year-old sample were willing to do so, they were asked to preclassify the eligible students on a judgment basis into two SES classes: (1) the lowest one-third and (2) the upper two-thirds. This information was used to more nearly balance the sample by SES class within schools through oversampling of the first category. Alternate sets of sampling instructions were used by field personnel in selecting respondents depending upon whether this additional information was provided by the school. This further classification and oversampling of the low SES students was not used in the 9- and 13-year-old samples.

2. Package assignment

An important part of the sample design was the method of assigning specific packages of exercises to schools in the sample. The sample design allowed every school with some enrollment of 9-year-olds, 13-year-olds, or 17-year-olds to come into the sample with a positive probability. Two different methods of package administration were used in the school sample:

(a) Group package administration to groups of 12 students

(b) Individual package administration

In addition, a special group interaction package was administered in a subsample of 32 PSU s by specially trained administration teams. The number of packages by type and by in-school age groups and the planned sample size per package are shown in Table 4.

Current-year estimates of enrollment for the sample age group were obtained in each sample school by field personnel on their first visit to each PSU. The package assignment procedure was then performed by central office sampling staff using a special random permutation procedure. By ranking schools in each PSU on the basis of an SES index and using a random permutation of group package numbers to assign packages to schools in the first PSU of a stratum and then using the same random permutation in reverse order to assign packages to schools in the second PSU in a stratum, some balance in the distribution of each package sample by SES was obtained. Specific instructions for the selection of students for each package were sent to field personnel prior to assessment week in each PSU.

3. Estimation

In the i-th PSU of the h-th stratum, estimates, $\hat{X}_{hi}$ and $\hat{Y}_{hi}$, are needed for formula (10) in Section II. These values are estimated on the basis of 12 responses for group package exercises and 9 responses for individual package exercises. For the j-th respondent to a package in the PSU and a specific target population estimate of P

Table 4

Package Types and Sample Sizes

Type of Package	Number of Packages			Planned Sample Size/Package	
	9 s	13 s	17 s	PSU s	Students
Individually administered	2	3	2	208	1872
Group administered	8	9	11	208	2496
Special group	1	1	1	32	1536

for a particular response category to a given exercise, the following variables are defined:

x_{hij} = 1 if the j-th respondent belongs to the target population

0 otherwise

y_{hij} = 1 if $x_{hij}=1$, and the respondent chose the particular response category to the exercise

0 otherwise.

The PSU values X_{hi} and Y_{hi} are then estimated as

$$\hat{X}_{hi} = \sum_j \frac{x_{hij}}{P_{hij}} \text{ , and} \qquad (11)$$

$$\hat{Y}_{hi} = \sum_j \frac{y_{hij}}{P_{hij}} \qquad (12)$$

where P_{hij} is the conditional probability of including the j-th respondent in a particular package sample given that the i-th PSU has been selected.

For group packages, the values P_{hij} depend upon three factors: (1) the number, G_{hij} , of group packages assigned to the respondent's school for the i-th PSU; (2) the number, R_{hij} , of eligible students in the respondent's school; and (3) the school factor, S_{hij} , as defined above, denoting the proportion of the school belonging to the i-th PSU.

For group packages, all 12 respondents generally came from one school. An individual's probability of selection for a group package for 17-year-old s, for example, where 11 group packages were used, is expressed as

$$P_{hij} = \left(\frac{G_{hij}}{11}\right)\left(\frac{12}{R_{hij}S_{hij}}\right) \qquad (13)$$

if SES preclassification had not been done, or

$$P_{hij} = \left(\frac{G_{hij}}{11}\right)\left(\frac{6}{R_{hij}S_{hij}}\right) \qquad (14)$$

if SES preclassification had been done. In formula (13), R_{hij} represents the number of eligible respondents in the school since it assumes no preclassification. In formula (14), R_{hij} represents an SES preclassification category within the school. Similar formulas to (13) and (14) are used for the appropriate P_{hij} for individual package respondents.

Respondents to individually administered packages generally came from several schools. The computation of the probabilities is somewhat more complex depending upon the method of assignment. In both cases, the appropriate expansion factor or weight, w_{hij}, for each response consists of two parts as follows:

$$w_{hij} = \frac{1}{P_{hij}} = \alpha_{hij} R_{hij} \qquad (15)$$

where α_{hij} is the part of $(1/P_{hij})$ computed in advance by the central office staff based on the methods of constructing PSU s and of assigning packages, and R_{hij} is the number of eligible students in the j-th student's school (and SES preclassification category if done).

The complete estimation formula assuming the planned sample sizes are realized is

$$\hat{P} = \frac{\sum_{h=1}^{L} \frac{N_h}{n_h} \sum_{i=1}^{n_h} \sum_{j} \alpha_{hij} R_{hij} y_{hij}}{\sum_{h=1}^{L} \frac{N_h}{n_h} \sum_{i=1}^{n_h} \sum_{j} \alpha_{hij} R_{hij} x_{hij}} \qquad (16)$$

In some cases fewer respondents actually participated in a particular package within a school than the planned sample size, n_{hij}, for that school. In order to utilize the n_{hij} as computed in advance,

a correction factor, f_{hij}, was computed to correct for the within school non-response. This was computed as

$$f_{hij} = \frac{n_{hij}}{n'_{hij}} \qquad (17)$$

where n_{hij} is the planned package sample size and n'_{hij} is the realized package sample size within a school. Note that if things proceeded as planned, the factor f_{hij} is equal to one and does not alter the calculation.

C. The Out-of-School Sample

1. The sample design

As discussed previously, each primary sampling unit in the household sample was defined within a larger geographic unit called a listing unit. The listing unit consisted of a contiguous land area bounded by county boundaries, city limits, or town boundaries (New England States). Generally, it was a county, a part of a county, a large city, or a combination of two or more such units.

The average size of a PSU was planned at about 16,000 persons. Large listing units contained several PSU s. Each individual PSU in the household sample was further defined as a systematic sample of secondary sampling units (SSU s) within the listing unit. For example, if a listing unit had a 1960 population of 46,000 persons, it was assigned three PSU s in the process of developing the sampling frame for primary sample selection. All SSU s in the listing unit were listed in a single or combined list; the ordering of the list was predetermined by the second stage stratification variable discussed in the next paragraph. The first of the three PSU s assigned to the listing unit was defined to consist of the 1st SSU, 4th SSU, 7th SSU, etc., in the combined SSU listing; the second PSU consisted of the 2nd SSU, 5th SSU, 8th SSU, etc.; the third PSU consisted of the 3rd SSU, the 6th SSU, 9th SSU, etc.

The secondary sampling units were defined to be clusters of 35 to 40 housing units on the average. Each SSU was expected to yield about 12 1/2 eligible adult respondents. Initial plans called for the selection of 10 SSU's per PSU. Stratified random cluster sampling was used to select these 10 SSU's. Local area SES data (percent of families earning less than $3,000) at the census tract or minor civil division level was used to order the list of smaller geographic areas within the listing unit by increasing income level. The stratification was then applied to the ordered list. The low SES end of the list (the one-fourth

with lowest income) was sampled at twice the rate of the remaining part of the list.

The basic within-PSU secondary sample stratification involved 5 secondary strata. Two sample elements were selected at random without replacement from each stratum. The first two strata were smaller than the remaining strata to effect the over-sampling of the low income or low SES population. The stratification is illustrated in Table 5 for a PSU with 152 SSU s.

2. Package assignment

Ten packages of exercises were compiled for the out-of-school adult sample, each containing a different subset of the exercises. To eliminate any excessive burden on individuals asked to participate, only one of the ten packages was administered to each adult respondent.

As eligible adult respondents were identified in the household screening process, each one was asked to complete a different package in package number sequence. A different starting package in the sequence was used in each of the 10 segments, so that all packages would be administered about the same number of times. As an example if the starting package in an SSU was 7, packages were assigned to respondents in the following order: 7, 8, 9, 10, 1, 2, 3, ...

Thirteen different packages were used for seventeen-year-olds. Each out-of-school seventeen-year-old was asked to respond to a set of 4 or 5 packages (two sets were made up of 4 packages; one set was made up of 5 packages); out-of-school seventeen-year-olds were given an incentive payment of ten dollars for completing the set of packages.

3. Estimation

Since all eligible respondents in each SSU (cluster of housing units) are in the sample, the probability of selecting a particular individual is the probability of selecting the SSU of which he is a member, or simply, (n_{hij}/N_{hij}) , where

N_{hij} = number of SSU s in the j-th secondary stratum of the i-th PSU of the h-th primary stratum.

n_{hij} = number of SSU s sample in the j-th secondary stratum of the i-th PSU of the h-th primary stratum.

The observations of a respondent on a particular exercise in a particular package are coded as:

Table 5

Example of Secondary Stratification
and Sample Allocation of the
Basic Household Sample

Secondary Stratum Number j	Number of SSU s N_{hij}	Number of Sample SSU s a_{hij}	Sampling Rate n_{hij}/N_{hij}
1	19	2	.1053
2	19	2	.1053
3	38	2	.0526
4	38	2	.0526
5	38	2	.0526
Totals	152	10	

$x_{hijk\ell}$ = 1 if the ℓ-th respondent in the k-th SSU of the j-th secondary stratum belongs to the population of interest and completes the package

0 otherwise.

$y_{hijk\ell}$ = 1 if $x_{hijk\ell}=1$ and the respondent chose the particular response category to the exercise

0 otherwise.

The PSU values of X_{hi} and Y_{hi} are then estimated as

$$\hat{X}_{hi} = \sum_j \frac{N_{hij}}{n_{hij}} \sum_{k=1}^{n_{hij}} \sum_{\ell=1}^{N_{hijk}} \frac{x_{hijk\ell}}{P_\alpha}$$

$$\hat{Y}_{hi} = \sum_j \frac{N_{hij}}{n_{hij}} \sum_{k=1}^{n_{hij}} \sum_{\ell=1}^{N_{hijk}} \frac{y_{hijk\ell}}{P_\alpha}$$

where P_α is the probability of selecting package α (1/10 for adults and 1/3 for seventeen-year-olds) and N_{hijk} is the total number of eligible respondents in the SSU.

Since not all of the sample households were screened, nor did all of the eligible respondents complete a package of exercises, it is necessary to modify the basic design weights to be applied to the observations in each SSU. Further modification is necessary to account for subsampling of large SSU s. The final estimation formula can be written with weights, W_{hijk}, as

$$\hat{P} = \frac{\sum_h \sum_i \sum_j \sum_k W_{hijk} \sum_\ell y_{hijk\ell}}{\sum_h \sum_i \sum_j \sum_k W_{hijk} \sum_\ell x_{hijk\ell}} \qquad (18)$$

where

$$W_{hijk} = \frac{N_h}{n_h} \frac{N_{hij}}{n_{hij}} F_{hijk} A_{hijk} \frac{1}{P_a} \qquad (19)$$

The subscripts used in (18) are reviewed as follows:

h denotes a primary stratum
i denotes a PSU within stratum h
j denotes a secondary stratum within a PSU
k denotes an SSU within a secondary stratum
ℓ denotes a respondent within an SSU.

Other terms in formula (18) are:

N_h/n_h = PSU expansion factor

N_{hij}/n_{hij} = SSU expansion factor

F_{hijk} = Adjustment for non-response

A_{hijk} = Special expansion factor for subsampled PSU s.

The estimation procedures discussed here apply generally to both target populations (adults and out-of-school 17-year-olds). Final estimates for all 17-year-olds involve further weighting of the results from the in-school and out-of-school samples.

APPENDIX D

Data For Nine Selected Science Exercises

(The full text of each exercise is given in Chapter 3.)

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APPENDIX D

Results for Exercise 319*

	Number in Group	% Correct	Difference: Group vs. All 17s	Approximate Standard Error of Difference	Difference Divided by its Standard Error	Statement About the Difference
All 17s	2114	53.8%				
Region						
Northeast	563	50.5%	-3.3%	2.76%	-1.20	--
Southeast	446	56.2	2.4	3.73	.64	--
Central	517	54.3	0.5	3.04	.16	--
West	588	55.7	1.9	2.55	.75	--
SOC						
Big City	504	52.5%	-1.3%	2.54%	-.51	--
Fringe	489	56.5	2.7	3.40	.79	--
Medium City	560	52.8	-1.0	3.06	-.33	--
Smaller Places	561	52.7	-1.1	2.67	-.41	--
TOC[a]						
Inner City	238	53.9%	0.7%	5.22%	.13	--
Suburb	165	45.7	-7.5	4.26	-1.76	may be lower
Rural	167	53.8	0.6	3.85	.16	--
Remainder	1458	54.0	0.8	1.02	.78	--
Sex						
Male	1019	49.6%	-4.2%	1.67%	-2.51	perhaps 4% lower
Female	1095	57.6	3.8	1.45	2.62	perhaps 4% higher
Color						
Black	282	55.0%	1.2%	4.23%	.28	--
Non-Black	1832	53.6	-0.2	0.63	-.32	--
Parents' Education[b]						
8th or below	151	50.3%	-3.5%	5.35%	-.65	--
Some High School	343	55.0	1.2	3.47	.35	--
HS Graduate	654	55.9	2.1	2.40	.88	--
Post High School	426	51.7	-2.1	1.87	-1.12	--

[a] The TOC subgroups include in-school 17s only. The assignment of out-of-school 17s to TOC categories is not yet completed. The overall % correct for in-school 17s = 53.2%. The differences between TOC subgroups and all 17s, shown in Column 3, uses this in-school value as the overall value.

[b] A fifth Educational Level category consists of respondents who could not be classified into one of these categories. The numbers are small, and are not shown.

* (17: 9-12) A [illegible] rock is dropped from a cliff 500 feet high. The longer the rock falls, the greater is its (speed).

APPENDIX D

Results for Exercise 324*

	Number in Group	% Correct	Difference: Group vs. All 17s	Approximate Standard Error of Difference	Difference Divided by its Standard Error	Statement About the Difference
All 17s	2214	45.9%				
Region						
Northeast	609	53.7%	7.8%	3.13%	2.49	perhaps 8% higher
Southeast	463	36.1	-9.8	2.73	-3.59	roughly 10% lower
Central	526	43.0	-2.9	2.46	-1.18	--
West	616	48.4	2.5	2.28	1.10	--
SOC						
Big City	521	42.4%	-3.5%	3.13%	-1.12	--
Fringe	538	49.8	3.9	2.19	1.78	may be higher
Medium City	573	47.4	1.5	3.09	.49	--
Smaller Places	582	42.1	-3.8	2.70	-1.41	--
TOC[a]						
Inner City	186	39.4%	-7.1%	4.95%	-1.43	--
Suburb	184	56.7	10.2	4.62	2.21	perhaps 10% higher
Rural	231	32.5	-14.0	3.77	-3.71	roughly 14% lower
Remainder	1514	48.0	1.5	1.09	1.38	--
Sex						
Male	1084	46.7%	0.8%	1.63%	.49	--
Female	1130	45.2	-0.7	1.49	-.47	--
Color						
Black	261	26.4%	-19.5%	3.18%	-6.13	about 20% lower
Non-Black	1952	48.1	2.2	0.39	5.64	about 2% higher
Parents' Education						
8th or below	165	41.1%	-4.8%	9.89%	-.49	--
Some High School	350	33.6	-12.3	3.04	-4.05	roughly 12% lower
HS Graduate	719	45.5	-0.4	2.22	-.18	--
Post High School	947	53.0	7.1	1.93	3.68	roughly 7% higher

[a] All in-school 17s = 46.5%.

* (17: 3-3) The musical note middle C is sounded on a violin string, and then C one octave higher is sounded on the same string. Which of the following is correct in comparing the two notes? (Upper C has a higher frequency and shorter wavelength.)

APPENDIX D

Results for Exercise 329*

	Number in Group	% Correct	Difference: Group vs. All 17s	Approximate Standard Error of Difference	Difference Divided by its Standard Error	Statement About the Difference
All 17s	2168	31.6%				
Region						
Northeast	594	34.0%	2.4%	2.87%	.84	--
Southeast	461	28.1	-3.5	2.69	-1.30	--
Central	533	30.2	-1.4	2.09	-.67	--
West	580	33.8	2.2	2.62	.84	--
SOC						
Big City	510	27.4%	-4.2%	2.36%	-1.78	may be lower
Fringe	513	35.6	4.0	2.62	1.53	may be higher
Medium City	577	30.8	-0.8	2.68	-.30	--
Smaller Places	568	30.4	-1.2	2.04	-.59	--
TOC[a]						
Inner City	201	23.7%	-10.1%	4.38%	-2.31	perhaps 10% lower
Suburb	243	45.4	11.6	4.46	2.60	perhaps 12% higher
Rural	179	29.6	-4.2	3.26	-1.29	--
Remainder	1452	33.1	-0.7	0.94	-.74	--
Sex						
Male	1038	37.7%	6.1%	1.46%	4.18	roughly 6% higher
Female	1129	26.4	-5.2	1.18	-4.41	roughly 5% lower
Color						
Black	261	13.4%	-18.2%	2.64%	-6.89	about 18% lower
Non-Black	1905	33.7	2.1	0.48	4.38	roughly 2% higher
Parents' Education						
8th or below	142	22.8%	-8.8%	4.96%	-1.77	may be lower
Some High School	338	18.6	-13.0	2.38	-5.46	about 13% lower
HS Graduate	667	28.3	-3.3	1.98	-1.67	may be lower
Post High School	978	41.0	9.4	1.51	6.23	about 9% higher

[a] All in-school 17s = 33.8%

* (17:7-10) Two light waves are traveling in a vacuum. The wave with the higher frequency will have the (shorter wavelength).

APPENDIX D

Results for Exercise 336*

	Number in Group	% Correct	Difference: Group vs. All 17s	Approximate Standard Error of Difference	Difference Divided by its Standard Error	Statement About the Difference
All 17s	2133	6.2%				
Region						
Northeast	58	7.4%	1.2%	1.25%	.96	--
Southeast	463	8.2	2.0	1.23	1.63	may be higher
Central	512	4.0	-2.2	0.87	-2.53	perhaps 2% lower
West	576	6.6	0.4	1.24	.32	--
SOC						
Big City	482	6.0%	-0.2%	1.30%	-.15	--
Fringe	501	6.1	-0.1	1.02	-.10	--
Medium City	577	6.2	0.0	1.31	.00	--
Smaller Places	573	6.3	0.1	1.14	.09	--
TOC[a]						
Inner City	132	1.4%	-5.3%	1.11%	-4.77	roughly 5% lower
Suburb	207	7.8	1.1	1.95	.56	--
Rural	152	5.1	-1.6	2.53	-.63	--
Remainder	1549	6.9	0.2	0.36	.56	--
Sex						
Male	985	8.8%	2.6%	0.63%	4.13	roughly 3% higher
Female	1146	4.1	-2.1	0.53	-3.96	roughly 2% lower
Color						
Black	243	5.2%	-1.0%	1.65%	-.61	--
Non-Black	1887	6.3	0.1	0.18	.56	--
Parents' Education						
8th or below	167	2.8%	-3.4%	1.03%	-3.30	roughly 3% lower
Some High School	301	5.3	-0.9	1.32	-.68	--
HS Graduate	677	6.2	0.0	0.95	.00	--
Post High School	949	7.6	1.4	0.71	1.97	may be higher

[a] All in-school 17s = 6.7%.

* (17:8-13) In the equation below, which of the following elements are oxidized?

$$SnS + 4HNO_3 \rightarrow S + SnO_2 + 4NO_2 + 2H_2O$$

(Tin and sulfur)

APPENDIX D

Results for Exercise 340*

	Number in Group	% Correct	Difference: Group vs. All 17s	Approximate Standard Error of Difference	Difference Divided by its Standard Error	Statement About the Difference
All 17s	2226	80.9%				
Region						
Northeast	603	80.6%	-0.3%	3.26%	-.09	--
Southeast	470	77.1	-3.8	2.49	-1.53	may be lower
Central	533	81.9	1.0	1.89	.53	--
West	620	83.0	2.1	2.60	.81	--
SOC						
Big City	510	80.1%	-0.8%	2.48%	-.32	--
Fringe	531	82.3	1.4	2.67	.52	--
Medium City	588	83.7	2.8	1.63	1.72	may be higher
Smaller Places	597	76.8	-4.1	2.18	-1.88	may be lower
TOC[a]						
Inner City	187	81.1%	-1.2%	2.91%	-.41	--
Suburb	270	92.4	10.1	1.68	6.01	about 10% higher
Rural	249	79.5	-2.8	3.85	-.73	--
Remainder	1420	80.8	-1.5	0.96	-1.56	may be lower
Sex						
Male	1125	80.7%	-0.2%	1.39%	-.14	--
Female	1100	81.0	0.1	1.42	.07	--
Color						
Black	249	57.1%	-23.8%	4.12%	-5.78	about 24% lower
Non-Black	1975	83.3	2.4	0.61	3.93	roughly 2% higher
Parents' Education						
8th or below	163	67.8%	-13.1%	6.84%	-1.92	may be lower
Some High School	341	73.9	-7.0	2.88	-2.43	perhaps 7% lower
HS Graduate	753	81.4	0.5	1.81	.28	--
Post High School	950	86.6	5.7	1.46	3.90	roughly 6% higher

[a] All in-school 17s = 82.3%

* (17:1-1) In each of five experiments, two objects were weighed four times each. Which experiment gives the strongest evidence that object I weighs more than object II? (For correct and alternative responses see page 111.)

APPENDIX D

Results for Exercise 341*

	Number in Group	% Correct	Difference: Group vs. All 17s	Approximate Standard Error of Difference	Difference Divided by its Standard Error	Statement About the Difference
All 17s	593	75.2%				
Region						
Northeast	159	84.0%	8.8%	3.02%	2.91	perhaps 9% higher
Southeast	124	64.7	-10.5	5.10	-2.06	perhaps 11% lower
Central	144	70.1	-5.1	3.20	-1.59	may be lower
West	166	81.0	5.8	3.01	1.93	may be higher
SOC						
Big City	148	70.5%	-4.7%	3.30%	-1.42	--
Fringe	139	82.3	7.1	3.05	2.33	perhaps 7% higher
Medium City	153	72.5	-2.7	3.59	-.75	--
Smaller Places	153	72.7	-2.5	4.15	-.60	--
TOC[a]						
Inner City	60	73.9%	-1.3%	5.78%	-.22	--
Suburb	53	76.9	1.7	5.64	.30	--
Rural	52	73.5	-1.7	8.55	-.20	--
Remainder	405	75.3	0.1	1.01	.10	--
Sex						
Male	299	81.1%	5.9%	2.12%	2.78	perhaps 6% higher
Female	294	68.8	-6.4	2.36	-2.71	perhaps 6% lower
Color						
Black	84	50.0%	-25.2%	5.80%	-4.34	roughly 25% lower
Non-Black	509	77.9	2.7	0.65	4.15	roughly 3% higher
Parents' Education						
8th or below	56	67.9%	-7.3%	8.24%	-.89	--
Some High School	102	64.5	-10.7	5.30	-2.02	perhaps 11% lower
HS Graduate	173	77.3	2.1	3.12	.67	--
Post High School	250	79.3	4.1	2.18	1.88	may be higher

[a] All in-school 17s = 75.2%

* (17:14-12a1) This apparatus exercise is given on page 111. The package in which this exercise appeared was individually administered. Individually administered packages were given to a smaller sample of respondents than were group administered packages; hence the smaller sample sizes shown on this page.

APPENDIX D

Results for Exercise 349*

	Number in Group	% Correct	Difference: Group vs. All 17s	Approximate Standard Error of Difference	Difference Divided by its Standard Error	Statement About the Difference
All 17s	2214	92.4%				
Region						
Northeast	609	93.5%	1.1%	1.44%	.76	--
Southeast	463	88.6	-3.8	1.56	-2.44	perhaps 4% lower
Central	526	92.4	0.0	1.07	.00	--
West	616	94.0	1.6	1.08	1.48	--
SOC						
Big City	521	90.7%	-1.7%	1.84%	-.92	--
Fringe	538	96.1	3.7	0.82	4.51	roughly 4% higher
Medium City	573	92.1	-0.3	1.16	-.26	--
Smaller Places	582	89.3	-3.1	1.43	-2.17	perhaps 3% lower
TOC[a]						
Inner City	186	90.0%	-3.7%	2.38%	-1.55	may be lower
Suburb	184	97.4	3.7	1.40	2.64	perhaps 4% higher
Rural	231	87.2	-6.5	2.71	-2.40	perhaps 6% lower
Remainder	1514	94.6	0.9	0.41	2.20	perhaps 1% higher
Sex						
Male	1084	91.8%	-0.6%	0.78%	-.77	--
Female	1130	92.9	0.5	0.70	.71	--
Color						
Black	261	77.8%	-14.6%	3.20%	-4.56	roughly 15% lower
Non-Black	1952	94.0	1.6	0.43	3.72	roughly 2% higher
Parents' Education						
8th or below	165	81.8%	-10.6%	4.54%	-2.33	perhaps 11% lower
Some High School	350	90.3	-2.1	1.72	-1.22	--
HS Graduate	719	91.4	-1.0	1.16	-.86	--
Post High School	947	96.9	4.5	0.72	6.25	about 4% higher

[a] All in-school 17s = 93.7%

* (17: 3-5) Skill in which of the following is most useful in scientific research? (Mathematics)

APPENDIX D

Results for Exercise 351*

	Number in Group	% Correct	Difference: Group vs. All 17s	Approximate Standard Error of Difference	Difference Divided by its Standard Error	Statement About the Difference
All 17s	2166	29.2%				
Region						
Northeast	570	37.0%	7.8%	2.69%	2.90	perhaps 8% higher
Southeast	479	26.5	-2.7	2.51	-1.08	--
Central	521	28.9	-0.3	2.15	-.14	--
West	596	24.6	-4.6	1.92	-2.40	perhaps 5% lower
SOC						
Big City	487	29.2%	0.0	2.73%	.00	--
Fringe	527	28.0	-1.2	2.00	-.60	--
Medium City	573	30.2	1.0	2.31	.43	--
Smaller Places	579	29.3	0.1	2.54	.04	--
TOC[a]						
Inner City	213	24.1%	-7.1%	3.97%	-1.79	may be lower
Suburb	230	39.7	8.5	4.47	1.90	may be higher
Rural	172	21.4	-9.8	2.66	-3.68	roughly 10% lower
Remainder	1459	32.2	1.0	0.89	1.12	--
Sex						
Male	1041	30.7%	1.5%	1.48%	1.01	--
Female	1124	28.1	-1.1	1.25	-.88	--
Color						
Black	263	23.7%	-5.5%	2.67%	-2.06	perhaps 6% lower
Non-Black	1901	30.0	0.8	0.34	2.35	perhaps 1% higher
Parents' Education						
8th or below	159	26.2%	-3.0%	4.94%	-.61	--
Some High School	332	15.2	-14.0	2.00	-7.00	about 14% lower
HS Graduate	743	28.5	-0.7	1.62	-.43	--
Post High School	881	37.2	8.0	1.30	6.15	about 8% higher

[a] All in-school 17s = 31.2%

* (17:2-5) Boyle's law, Charles' law, and Graham's law dealing with the behavior of gases can all be generalized in terms of which of the following? (Kinetic-molecular theory).

APPENDIX D

Results for Exercise 352*

	Number in Group	% Correct	Difference: Group vs. All 17s	Approximate Standard Error of Difference	Difference Divided by its Standard Error	Statement About the Difference
All 17s	2202	81.3%				
Region						
Northeast	588	83.8%	2.5%	1.44%	1.74	--
Southeast	469	74.9	-6.4	2.18	-2.94	perhaps 6% lower
Central	533	81.7	0.4	1.38	.29	--
West	612	83.0	1.7	1.47	1.16	--
SOC						
Big City	503	79.2%	-2.1%	2.38%	-.88	--
Fringe	527	83.7	2.4	1.61	1.49	--
Medium City	577	82.1	0.8	1.45	.55	--
Smaller Places	595	79.3	-2.0	1.59	-1.26	--
TOC[a]						
Inner City	256	78.6%	-4.8%	4.04%	-1.19	--
Suburb	247	85.0	1.6	2.11	.76	--
Rural	217	83.9	0.5	2.91	.17	--
Remainder	1390	83.7	0.3	0.75	.40	--
Sex						
Male	1073	80.5%	-0.8%	1.16%	-.69	--
Female	1128	81.8	0.5	1.03	.49	--
Color						
Black	277	73.7%	-7.6%	4.03%	-1.89	may be lower
Non-Black	1923	82.1	0.8	0.50	1.60	may be higher
Parents' Education						
8th or below	161	67.6%	-13.7%	5.17%	-2.65	perhaps 14% lower
Some High School	373	71.8	-9.5	3.00	-3.17	roughly 10% lower
HS Graduate	702	82.5	1.2	1.21	.99	--
Post High School	925	87.1	5.8	1.05	5.52	about 6% higher

[a] All in-school 17s = 83.4%

* (17: 11-4) Most scientists (want to know more about the world).

APPENDIX E

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APPENDIX F

NUMBER OF RESPONSES FOR YEAR 01, BY PACKAGE AND AGE[a]

Package Number	Age 9	13	17	Adult
1	2455	2436	2226[b]	895
2	2389	2421	2166	875
3	2466	2416	2214	860
4	2456	2415	2171	877
5	2463	2407	2200	892
6	2419	2410	2194[b]	885
7	2424	2396	2168[b]	920
8	2406	2441	2133	893
9	1438	2383	2114	903
10	1863	1412	2173	634
11	1852	1883	2202	—
12	—	1855	1315	—
13	—	1844	1797	—
14	—	—	1771	—
Total	24631	28719	28844	8634

At the request of state and local authorities, some exercises were not given in certain parts of the country, and the number of respondents was reduced as indicated below.

Age	Package	Exercise	Number of Respondents
9	11	21	1837
13	11	18	1667
13	12	19	1637
13	13	4	1595
13	13	13	1821
17	14	10	1930
17	11	9	1966
17	13	9	1595

[a] Since the Science and Citizenship reports were written, exact figures for respondents became available and are shown above. For each age, the total number of exercises was divided into packages so that each participant would spend only about 50 minutes completing his set of exercises. As the above table shows, there were different numbers of packages for the different ages since the total number of exercises and the time needed to complete them varied from age to age.

Some participants--the out-of-school 17s--were asked to take four packages, and they were paid $10 for their time. Because some people responded to more than one package, the number of responses to some packages is greater than the number of respondents.

The age/package/exercise number code is found in the upper left corner of each exercise page in this report. For example, a code of 9:11-21 indicates age 9, package 11, and exercise 21.

[b] There were no Citizenship exercises in this package.

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